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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CIX.—No. 2827.] LONDON: FRIDAY, MARCH 5, 1920. [Registered at the General Post Office as a Newspaper.] PRICE... 1s. BY FOREIGN POST ... 1s. 6d.

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See page 15, Feb. 27. 8421

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See Advertisement page 38. 8187

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See Advertisement page 96, Feb. 27. 2402

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See half-page Advertisement page 33, Feb. 20.

See Advt. Page 26, Feb. 27.
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TENDERS.

COUNTY BOROUGH OF WALLASEY.

WATER WORKS.

TO STEAM BOILER MAKERS.

The Wallasey Corporation invite

Tenders for the Supply,

DELIVERY and FITTING of NEW FURNACE RINGS in FURNACES of LANCASHIRE BOILERS, at the Pumping Station, Seaview Road, Wallasey, Cheshire.

Further particulars may be obtained on application to the Engineer, Mr. J. H. CROWTHER, at the Gas Works, Limekiln Lane, Wallasey. Sealed Tenders, addressed to the undersigned, and endorsed "Repairs to Lancashire Boilers," to be delivered per post to my office, as below, not later than the morning of the 16th March, 1920.

Tenders arriving after that time will not be considered.

The Corporation do not bind themselves to accept the lowest or any tender.

Dated this 20th day of February, 1920.

By Order,
H. W. COOK,
Town Clerk.
Town Hall, Wallasey. D 977

TO LAUNDRY ENGINEERS AND OTHERS.

The METROPOLITAN ASYLUMS BOARD invite separate

Tenders for Providing and

FIXING TWO WASHING MACHINES, one in each Laundry at

(a) Tooting Bec Mental Hospital, Tooting Bec Road, Tooting, S.W. 17.

(b) North Western Hospital, Lawn Road, Hampstead, N.W. 3,

in accordance with drawings and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The drawings, specification and form of tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m. on Friday, 5th March, 1920, and the drawings, specification and form of tender can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a bona-fide tender sent in accordance with the instructions on the form of tender, and after the specification and the drawings have been returned. Tenders addressed as noted on the form must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 17th March, 1920.

(By Order) DUNCOMBE MANN,
Clerk to the Board.
F 16

METROPOLITAN WATER BOARD.

TENDER FOR LAYING MAINS FROM CARPENTERS ROAD, POPLAR, TO BECKTON ROAD, EAST HAM.

The Metropolitan Water Board invite

Tenders for Laying 36 in.,

30 in., and 24 in. C.I. MAINS from Carpenters Road, in the Borough of Poplar, to Beckton Road, in the Borough of East Ham.

Tenders must be made on official forms, which may be obtained at the Offices of the Board, Chief Engineer's Department, South Place, Finsbury Pavement, E.C. 2, on and after Monday, 1st March, 1920, by personal application or on receipt of a stamped addressed brief envelope.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, South Place, Finsbury Pavement, E.C. 2," and endorsed "Tenders for Laying Mains, Poplar and East Ham," must be delivered at the Offices of the Board not later than Eleven a.m., on Monday, 15th March, 1920.

The Board do not bind themselves to accept the lowest or any tender.

A. B. PILLING,
Clerk of the Board.
South Place, Finsbury Pavement, E.C. 2.
26th February, 1920. F 32

LONDON COUNTY COUNCIL.

Tenders are Invited for Supply

of Two MOTOR CARS, Seven TRADE VANS, Two TANK WAGONS, Two TRAILERS, 10 MOTOR LORRIES, and Seven STEAM WAGONS, for use on the Council's tramways. Particulars and forms of Tender may be obtained, on payment of a deposit of 21s. to the Cashier of the Council, from the Clerk of the Council, County Hall, Spring Gardens, S.W. 1. No Tender received at the County Hall after Eleven a.m. on Tuesday, 23rd March, 1920, will be considered.

JAMES BIRD,
Clerk of the London County Council.
F 38

EDMONTON URBAN DISTRICT COUNCIL.

SYREN FOR SALE.

The Council have

For Disposal, a Steam Syren

of Navy pattern, which may be seen at Deepham's Farm, Edmonton, on application to the Council's Engineer, Mr. CUTHBERT BROWN, Town Hall, Edmonton.

Offers for same in sealed envelopes, marked "Syren," should reach me by Twelve o'clock noon on Monday, the 15th March.

The Council do not bind themselves to accept the highest or any Offer.

By order,
FREDK. W. CLAXTON,
Clerk.
Town Hall, Edmonton.
2nd March, 1920. F 35

CLYDE NAVIGATION.

PLANT FOR SALE AT PRINCE'S DOCK POWER STATION.

The Trustees Invite

Tenders for the Purchase of

disused Plant at Prince's Dock Power Station consisting of a Bellis Double-Acting Compound Steam Engine on combined soleplate coupled to a Silvertown Compound Dynamo of 60 K.W. and 250 volts D.C.; a Mirrlees Watson Single-Acting Compound Steam Engine with Dynamo of similar type and size; also steam and exhaust pipes, etc., and seven Marble Panel Switchboards with fittings.

The Purchaser to take down and remove the plant when required by the Trustees.

For particulars apply to the Mechanical Engineer, 16, Robertson Street.

Tenders to be lodged with the undersigned not later than Monday, 22nd current.

The Trustees may not accept the highest or any Tender.

T. R. MACKENZIE,
General Manager and Secretary.
16, Robertson Street, Glasgow.
3rd March, 1920 F 16

CITY OF MANCHESTER.

The Electricity Committee of the Manchester Corporation are prepared to receive

Tenders in connection with

the construction of their proposed new Generating Station at Barton-upon-Irwell, near Manchester, for:—

CONTRACT No. 1.—The CONSTRUCTION of a NEW ROAD, including a Road and Railway Bridge over the Bridgewater Canal, a Canal Dock, foundation work and other works.

CONTRACT No. 2.—STEELWORK for Road and Railway Bridge over the Bridgewater Canal.

Specifications, quantities and forms of Tender may be obtained on application to Mr. F. H. HUGHES, Secretary, Electricity Department, Town Hall, Manchester, on payment of a deposit of £3 3s. 0d., which amount will be refunded on receipt of a *bona fide* tender.

Drawings may be seen at the offices of Messrs C. S. ALLOTT & SON, Civil Engineers, 46, Brown Street, Manchester, on and after Wednesday, the 10th instant.

Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall not later than Twelve noon on WEDNESDAY, the 24th instant.

The firm entrusted with this work will be required to enter into a contract to be prepared by the undersigned.

The Corporation do not bind themselves to accept the lowest or any tender.

THOMAS HUDSON,
Town Clerk.
Town Hall, Manchester.
4th March, 1920. F 46

CITY OF BIRMINGHAM WATER DEPARTMENT.

COVERED SERVICE RESERVOIR AT HIGHTER'S HEATH, YARDLEY WOOD.

The WATER COMMITTEE of the CORPORATION OF BIRMINGHAM are prepared to receive

Tenders from Competent

persons willing to enter into a contract for the COMPLETION of the COVERED RESERVOIR and CONNECTIONS at Highter's Heath, Yardley Wood, in the City of Birmingham.

The Drawings may be seen and Specifications and Bills of Quantities obtained at these offices on and after Wednesday, 3rd March next, on the deposit of the sum of £5 which will be returned after the receipt of a *bona fide* Tender with the Bills of Quantities fully priced out. Tenders must be based upon the Drawings, Specifications and Estimates provided. Persons tendering will be required to quote for a quantity of material already on the ground as set out in the Specification.

The site at Highter's Heath may be inspected at any time by appointment.

Early application for particulars is necessary as only a limited number of Specifications will be issued, and none after Monday, 15th March, 1920.

The Contractor will be required to undertake not to pay less than the minimum standard rate of wages current in the district in which the works are situate.

Sealed Tenders addressed to me, and endorsed "Tender for the Completion of Highter's Heath Reservoir," are to be delivered at these offices at or before noon on Monday, 29th March, 1920. The Corporation do not bind themselves to accept the lowest or any Tender.

B. ANTONY LEES,
Council House, Edmund St., Birmingham, Secretary.
February 26th, 1920 D 963

QUEENSLAND GOVERNMENT.

THE AGENT-GENERAL FOR QUEENSLAND invites

Tenders for 114 Tons

GALVANIZED SHEETS, delivery of which is required in June next.

Tenders will be received at the Office of the AGENT-GENERAL FOR QUEENSLAND, 409/410, Strand, London, W.C. 2, until noon on the 22nd day of March, 1920.

Specification, Schedule of Quantities and Form of Tender can be obtained from the Office of the Executive Engineer. F 56

HYDE CORPORATION.

Tenders are Invited from

Manufacturers for a 10-ton STEAM ROLLER. Tenders, with Specifications, stating earliest date for delivery, to be in my hands not later than the 27th instant, endorsed "Road Roller." The Corporation do not bind themselves to accept the lowest or any Tender, and makers should comply with the Council's Standing Order as to rate of wages and conditions of labour.

THOS. BROWNSON,
Town Clerk.
Town Hall, Hyde.
3rd March, 1920. F 111

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

No.		Fees for Specification.
1.	Steel Work for Bridges	£1
2.	Galvanized Wrought-iron Water Tubes, etc.	10s.

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steelwork for Bridges," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 16th March, 1920.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.
Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 3rd March, 1920. F 88

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

CITY OF LINCOLN MUNICIPAL TECHNICAL SCHOOL.

A. H. COLLIS, M.I.M.E.—Principal.

Applications are invited for

the POST of ASSISTANT LECTURER in the Mechanical Engineering Department.

Candidates will be required to take day and evening classes. University degree or equivalent qualification. Works' experience and Laboratory Practice essential.

Commencing Salary £275–£325 according to experience and qualifications rising by annual increments of £12 10s. to £400.

Form of application and further particulars may be obtained from the PRINCIPAL to whom applications should be returned not later than March 20th, 1920. D 740

CORPORATION OF CALCUTTA.

APPOINTMENT OF LIGHTING SUPERINTENDENT.

Applications are Invited for

the POST of LIGHTING SUPERINTENDENT, Calcutta. The salary of the appointment, inclusive of all allowances, is Rs. 750 rising to Rs. 1000 per month by biennial increments of Rs. 50. The Corporation provide a motor car for the use of the Lighting Superintendent and his staff, free of charge, for inspection work.

The appointment is subject to the Provident Fund, leave and other service rules of the Corporation, and may be terminated at any time by six months' notice on either side. The Provident Fund contribution is 6¼ per cent. of the monthly salary and an equivalent amount is contributed by the Corporation, and the fund accumulates at compound interest. The select candidate will be required to devote his whole time to the duties of his office, and will not be allowed to take up any outside work. He must reside in Calcutta. He will be liable to removal during the term of his office for misconduct, or neglect of, or incapacity for his duties. He will be required to submit to a medical examination before joining his appointment. The Corporation will pay his passage (first class) from London to Calcutta, but he must refund the amount so paid if he gives notice within two years from the date of taking up his appointment. He will be required to take up his appointment about the 1st August, 1920, and will receive half pay for the period occupied by his journey.

(b) There are about 12,000 incandescent gas lights in the city, besides a number of electric and oil lights. Gas and electricity are supplied by public companies. The Lighting Department of the Corporation are responsible for the maintenance of the public street lamps, and also of about 2300 lights and 800 electric fans in Municipal Buildings. Candidates must have experience of the Management and control of the Lighting Department of a large town. They must have thorough and up-to-date knowledge of mantles, burners, etc., photometric work, testing pressure, and determining the discharging capacity of burner nipples. They must also have a general knowledge of electrical work.

(c) Candidates should state their age and experience.

(d) Applications will be received by the Secretary to the Corporation of Calcutta, Central Municipal Office, Calcutta, up to 1st May, 1920.

J. C. MUKERJEA,
Secretary to the Corporation.
28th January, 1920 D 877

Assistant Master Required

for Works School. Must have had experience in teaching elementary applied maths. and science and machine drawing. Salary £260 to £300, according to qualifications. Replies must be received by March 12th.—Address, THE SUPERINTENDENT, Royal Aircraft Establishment South Farnborough. D 987

WOOLWICH POLYTECHNIC.

ENGINEERING DEPARTMENT.

Wanted, Teacher of Drawing.

Commencing salary £275, rising by annual increments according to L.C.C. scale to a maximum of £340.

ASSISTANT LECTURER IN ELECTRICAL ENGINEERING. Commencing salary £295–£315, according to previous experience, and rising by annual increments according to L.C.C. scale, to a maximum of £440.

For further particulars, apply PRINCIPAL. F 62

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

DEPARTMENT OF METALLURGY.

The Governors invite

Applications for the Pro-

FESSORSHIP OF METALLURGY, vacant by the transfer of Dr. C. H. Desch to the University of Sheffield.

Applications must be sent not later than March 20th, to the DIRECTOR, The Royal Technical College, Glasgow, to whom inquiries should be addressed. D 868

GUILDFORD JUNIOR TECHNICAL SCHOOL.

Two Assistant Masters Re-

QUIRED 1st April next. One to Teach Engineering Subjects, principally Machine Drawing and Applied Mechanics. Works and Drawing Office experience essential—degree in Engineering desirable. One with Works experience to Teach Workshop Practice and Metal Work.

Either may be required to teach part time (not more than three evenings weekly) in the Technical Institute Evening Engineering Courses. Extra payment for time exceeding 10 Sessions. Scale salary, Graduates minimum £230, maximum £400. Non-Graduates minimum £185, maximum £300. Allowance up to 10 years for past experience.

Applications, stating age, qualifications and works and teaching experience, with copies testimonials, to

F. S. TOSSWILL,
Technical Institute, Guildford. Clerk to the Governors.
28th February, 1920. D 852

LONDON COUNTY COUNCIL.

There are Vacancies for the

following WHOLE-TIME POSITIONS at the L.C.C. Paddington Technical Institute, Saltram Crescent, W.:—

(1) DEMONSTRATOR IN MECHANICAL ENGINEERING.

(2) DEMONSTRATOR IN ELECTRICAL ENGINEERING.

Candidates should possess a good honours University degree or its equivalent, but the qualification will not be insisted upon in the case of candidates otherwise exceptionally qualified. Practical experience in addition to scientific qualifications is essential. Commencing salary £225 to £315 a year, according to qualifications and experience, rising to £330 by yearly increments of £15, thence by yearly increments of £10 to £440 a year.

Preference will be given to candidates who have served or attempted to serve with the Forces of the Crown.

Application forms may be obtained from the EDUCATION OFFICER (T.1), Education Offices, Victoria Embankment, W.C. 2 (stamped addressed foolscap envelope necessary). Form must be returned by 11 a.m., on 15th March, 1920. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
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LITERATURE.

The Construction of Graphical Charts. By JOHN B. PEDDLE, Professor of Machine Design, Rose Polytechnic Institute. Second edition, revised and enlarged. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 10*s.* net.]

THIS is a very useful book, clear in its methods and suggestive in its scope. That it has passed into a second edition is rather a matter for congratulation than surprise, for this increased circulation implies an increased interest on the part of the public in the employment of processes that give with the least trouble the fullest information in the most instructive manner. This widened attention is well illustrated by the introduction of a problem that was suggested by a maker of blue prints, who applied to be furnished with a diagram for calculating the areas of his prints as a guide for fixing his charges. The problem is, of course, quite simple and intended only to illustrate elementary principles, but the demand for such a diagram is instructive, mainly on two grounds. Such a request demonstrates that the public is growing aware that mathematical science can be of assistance in the conduct of ordinary business, and secondly it suggests that it is not easy to find those who are sufficiently familiar with the general principles underlying graphical construction, and who can also adapt and apply the method to purposes outside their ordinary experience. Many, no doubt, can exhibit graphically the consequences arising from the substitution of a succession of numerical values in the variables in a particular equation. The process has become mechanical from frequent repetition, but faced with a new type of problem, the limited experience at command is found inadequate. Complete mastery of the theoretical basis on which the various devices are built is necessary to educe the full benefits of a process so well calculated to lighten the heavy arithmetical computations, with which the physicist and the engineer are so often faced. A graphical method invented, it may be, to cope with a particular problem appeals to a student by the ingenuity with which it avoids calculation, or the skill with which it interprets a formula. The scheme becomes generally recognised as applicable in one direction, and though the device might be of equal value in some other direction, the necessary modifications are impossible for want of the knowledge of the general principles on which the scheme is based. It is precisely to make clear the mathematical treatment involved, to ensure systematic study of the whole process, and to display the elasticity of the method in many directions, that Professor Peddle has designed this work. The variety of application is illustrated by fully worked problems, which the author rightly maintains will afford a clearer insight into the methods, and more effectively remove the difficulties that have to be encountered, than is possible by the exhibition of a purely theoretical analysis.

The first two chapters are devoted mainly to the description of methods of plotting on sectional paper, equally divided, or adapted to a logarithmic scale. The simplicity of rectangular co-ordinates and the advantages of employing parallel co-ordinates are treated in sufficient detail, and some simple problems are worked out to illustrate the general method of treatment in practice. The choice of a modulus suitable to the problem under consideration is a matter of great practical importance, and the student's attention is directed to the management of the "support" of the points of intersection whether rectilinear or curved. While fully appreciating the value of the worked out problems in detail one would have welcomed a larger number of examples for practice, in order that students might acquire the necessary facility of construction. Though warnings are given to avoid ill-conditioned figures, nothing is said of the possibilities of absolute failure. But just as in the method of the solution of equations by the method of approximation it is possible under well-known circumstances to approach the value of the unknown without attaining an accurate solution, so problems might arise which fail to be represented by a graphical construction. It is not a very profitable exercise to seek for failures, the more readily admitted as our amateurish attempts have not been successful, but one would like to know in what forms a failure would declare itself.

A chapter on the construction of diagrams involving more than three variables, shows a great increase in complication, and though practical rules are considered for the avoidance of errors, the necessity of very considerable practice is to be inferred in order to acquire the necessary familiarity in obtaining and interpreting the results. The treatment of an equation containing four variables is effected by dividing the process into two steps, and this is probably the form that would recommend itself to the less expert, but the device of the hexagonal chart, which cannot be said to increase the confusion, if a transparent hexagonal index is used, simplifies the construction and as a rule lends itself to the more convenient handling of problems involving a large number of variables. The author gives an example founded on the fundamental optical equation worked out by two methods, but so simple an expression as $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ does not do justice to the ingenuity of the method. While acknowledging the advantages of the hexagonal chart and admitting that occasionally it may offer the only means of handling particular problems with any approach to simplicity, he utters a word of warning. His experience has taught him that it is easier to "fudge" or force the index to give the desired result, than with most of the other methods. This remark raises a question which we should have liked to have seen fully discussed; the amount of error or the degree of accuracy that is to be expected in graphical construction. The error, of course, depends on many variables and might itself be made the subject of a problem to illustrate a subsequent section on "Empirical Equations." In the absence of more precise information, an example founded on a formula for computing the resistance of earth to compression, useful in calculations connected with strength of foundations, seemed suitable for deriving the value in a particular case. Unfortunately the variables chosen for the illustration were such that the exact answer could be determined at sight. Using other values it was found that the percentage of error amounted to about 1½ per cent.; an expert would probably be within 1 per cent., but it may be doubted if greater accuracy is generally attainable. The author rightly insists on the importance of accuracy, but he makes no attempt to define an "unsatisfactory result."

In the chapter on "Empirical Equations" the aim of the author is to derive from the plotted diagram which represents observed facts, an algebraical expression or a continuous curve that will reproduce the disconnected data. It is in fact the reverse process to that hitherto employed. It would be too much to say that he endeavours to find a law which will connect the observed data, for the selected curve may have no physical relation to the data, but simply offers a means for calculating results of the same general character as the observations. The plan is really nothing more than an attempt to draw by eye estimation a continuous curve among the observations and to assume its character. Professor Peddle seems to regard this plan as an efficient substitute for the method of least squares. In a sense, the curve so drawn takes the place of a normal equation, and furnishes a criterion for the rejection of discordant observations, but as we, think, very imperfectly. All observations are treated as of equal weight, and it is recommended that the curve be drawn through the regions of greatest density. The author is aware of the limitations of his method, for he warns us against the danger of extrapolation. The author is too deeply enamoured of the machinery that he describes so well and handles so deftly. His condemnation of a method that has met with such unanimous approval is far too sweeping. It is described as "tedious and laborious in the extreme, even under the most favourable circumstances, while for certain forms of equations the difficulties of the method are so great that it can hardly be considered as practicable." It would have been more just to have said that however operose and wearisome the method may prove, no other is known that is generally applicable and gives results of equal accuracy. It is false economy to spend much time and thought in the collection of data and to stint or grudge the time required to discuss the material in the most thorough manner. We admit very heartily the success that has attended the selection of the form of expression to fit the selected observations operated upon, and we have nothing but admiration for the skill and ingenuity with which the analysis has been effected.

The master hand is also shown in describing the construction of three-dimensional charts, an extension of the elementary scheme which permits the representation of two variables and a function, with continuous variation for all three. It is an extension, it is contended, which has thrown much light upon obscure phenomena owing to the facility with which it is possible to detect the maximum and minimum conditions and rates of change among variables whose relation is complex or unknown. Doubtless both the construction of the model and the interpretation of the results demand very considerable experience, and we imagine that few who are expert in the use of the two-dimensional chart have penetrated far into this more complicated study. Of course, there is a form of chart, of which the synoptic weather map is a good example, in which contour lines are made to convey a good idea of the undulating surface they represent. The idea is capable of considerable extension, but the author describes skeleton and solid models which are far more instructive than the inferences from the study of contour lines can possibly be. The examples given are of such a fascinating character that one might easily be tempted to embark on this species of investigation. The solid models may possess some advantages by reason of the continuity of surface, but the axonometric projections are more inviting by their constructive ingenuity. An example is given of a solid model to show from data derived from a gas engine, the relation between the heat units per hour per brake horse-power, the compression pressure in atmospheres and the volume of mixed gas and air per 1,000 heat units of lower heating value. This is a sufficiently intricate problem to treat as a whole by charting, and the interpretation of the features and deductions from the model seem positively uncanny. The model has, indeed, justified its construction.

After the skilful handling of such complicated quantities the final chapter on the use of determinants comes almost as an anticlimax. The aim is to make the notation of determinants available to those who are unfamiliar with the device, a plan of doubtful utility and one that is generally unsatisfactory. Any of the examples could, we imagine, be worked by processes previously explained, and the points that appeal to the mathematician would probably be overlooked by those who are working without sufficient mastery over the tools they are employing. There is no very great demand on the purely mathematical principles, and the author is no doubt justified in claiming, that any one possessing the mathematical knowledge which an engineer should possess, can understand and apply the process with but little difficulty. But little advantage accrues in substituting a method that is imperfectly understood for the simpler geometry that is readily apprehended from its more familiar notation.

The process of charting has before it a field of great usefulness, its capacities have not yet been fully realised and the literature available is scanty. Professor Peddle has rendered a very great service in pointing out the elasticity of the method, the various directions in which it can be utilised, and its value for facilitating investigation.

Aeroplane Structures. By A. J. SUTTON PIPPARD, M.B.E., M.Sc., and Captain J. LAWRENCE PRITCHARD, late R.A.F. London: Longmans, Green and Co. [Price 21*s.* net.]

THE volume under review is one of one of the most valuable aeronautical text books that has so far appeared, and only readers who are familiar with the enormous mass of undigested information on aeronautical subjects now available can realise the problem of selection with which the authors have had to deal. Still fewer will be able to appreciate

the high quality of the selective judgment which has been brought to bear throughout, and which gives the book a really exceptional value. The aerodynamical phenomena which account for the external forces on an aeroplane in flight, are only touched on, but sufficiently so to enable the student to refer to specialist work on this extensive subject.

The diagrams, Figs. 1 and 2, given by the authors, may seem simple and obvious to the aerodynamical expert, but they are in welcome contrast with the absurd fictions found in so many text books of aeronautics, in fact they do represent with reasonable descriptive accuracy two types of flow with which we are familiar, steady flow of a stream between channel boundaries, and steady flow of a free stream of indefinite extent past a fixed object of relatively small dimensions.

The main features in the construction of an aeroplane are described, by the aid of an admirable series of photographs and diagrams, in Chapters III and IV, while Chapters V and VI deal not less adequately with the principle manœuvres and their effect in throwing stresses on the frame structure. Appendix III gives a judicious selection of the best experimental aerofoils and enables the designer to choose a suitable wing form for each special type of aeroplane. The chapters on detailed design are full of the very best matter, the fruit of long years of experience, while the chapter on testing is an adequate introduction to this important branch of work.

An exception to the standard of clearness must be marked in Section 39, Chapter VI, dealing with the load on the tail in a nose dive. The symbols are mostly novel and inappropriate. At least twice as many symbols are introduced as need be, the choice of variables seems lacking in directness and simplicity, and simplifications are introduced at the end which seem to the reviewer to be suggested at the beginning by general physical principles. Altogether the section could be rewritten in much better form, and should be recast, the results being such as are continually required by the designer. Chapters VII to X (Section 89), on the strength of materials, are saved from banality by interesting examples drawn from aeroplane practice, the diagrams being notably good.

From Section 90, Chapter X, onwards the student is introduced to recent developments in the theory of structures, further examples on struts being given in Chapter XVIII, Section 155 to 174. Euler's [1] theory of long struts, under simple end loading, Clerk Maxwell's [2] principle of the superposability of systems of loading, and Castigliano's [3] principle of least work, together with Clapeyron's [4] theorem of three moments, are the foundation on which the enormous literature of stresses in framed structures has grown up. In 1880 Manderla [5] considered the case of a beam with distributed load, end thrust and end-fixing moments, and thus obtained a linear differential equation with constant coefficients in place of the usual equation with separable variables. Had Manderla applied Clapeyron's device of equating the slopes of adjacent bays of a continuous beam at the nodes, he would have at once obtained an important generalisation of Clapeyron's theorem. It may be noted that the solution of Euler's equation for long struts gives the general integral of Manderla's equation. Unaware of Manderla's work, Perry [6] has given an approximate and Morley [7] an exact solution of a less general case of Manderla's problem, the fixing moments at the ends of the beam being considered zero.

The problem of the continuous beam with combined end thrust and side loading occurs in aeroplane design, and was raised in the Royal Aeronautical Society [8] and a method of approximate solution was given, depending on the assumption that the points of inflection did not shift with increasing end thrust from the position with end loading zero. A formal solution was obtained by Booth and Bolas [9] by the combination of Manderla's method and Clapeyron's method on certain simplifying assumptions, and was put in a form suitable for design-room calculation by Berry [10], who introduced three trigonometrical functions, which he tabulated, thus reducing the computation of examples to manageable dimensions. Berry also made extensive improvements in the notation and in the form of the solution. Two out of the three functions are not new, and are to be found in Mueller-Breslau's text books prior to 1914, but the third is introduced by the combining of Manderla's and Clapeyron's methods. However, as Berry was the first to introduce all three into design-room practice by his tabulation, and as he actually derived the third in the course of his transforming the solution of Booth and Bolas into manageable form, they are appropriately known—at least by English writers—as "Berry" functions.

Cowley and Levy [11] have collected most of the results in their paper, and L. N. G. Filon [12] has given his own form of discussion in reference to a comparison of results with those obtained by stress-optical methods in Professor Coker's laboratory at University College, London. Most of the papers referred to antedate the claim of recent correspondents in ENGINEERING to priority in the solution of the case where the points of support do not remain collinear. Manderla's results have lain almost unnoticed for a generation, probably because his assumptions invalidate Clerk Maxwell's linear relations, replacing them by transcendental relations which do not lend themselves to elimination in the same simple way.

In Castigliano's method of least work, the simple quadratic relations between strain and strain energy are replaced by transcendental relations of a highly intractable form.

The mathematical difficulties of the extended Theorem of Three Moments are trivial, from the point of view of the professional mathematical physicist, but the assumptions made are so shaky that probably no physicist would have thought of making them.

With regard to the assumption that the nodes are collinear, or at least fixed, in a number of observed cases the node nearest the point of support had the largest departure from collinearity, and this departure decreased with increasing load, a result that could not be predicted without going further into the deformation of all parts of the frame other than the bending of the main spars which alone have been considered hitherto.

This interesting chapter of the history of the theory of structures may be concluded with a reference to the recently-published German Confidential Technical Reports [13], in which the subject has been written up in a masterly fashion by Mueller-Breslau, and includes a table of values of "Berry" functions. A reference to the introduction of the "Berry" functions in this author's "Graphische Statik" is given, which must refer to a more recent edition than the reviewer has been able to consult. Generally speaking, the same ground is covered as in the corresponding English confidential publications, but with an apparent time lag of from one to two years, a most satisfactory state of affairs from the British point of view. No reference is made to confidential English publications by the various German authorities.

The introduction of Berry's methods into British practice was very largely due to the enthusiasm of the joint authors of the book under review, and in the latter part of Chapter X, as already stated, the student will find an adequate presentation of Berry's work, while the Berry functions are tabulated in Appendix I. Further original work by Berry, Webb [14], Southwell [15] and others will be found in the discussion of strut design in Chapter XVIII.

The whole treatment of the detail design of an aeroplane is of the most invaluable kind from the point of the routine designer as well as of the research student. Chapter XXII gives a sound introduction to Castigliano's principle of least work. The authors should, however, at least refer to Martin [16], Hiroi [17] and Church [18], as well as to the translation of Castigliano's text book which appears with E. S. Andrews' [19] name on the cover, evidently by inadvertence. Their statement that no English writers have made the method available is not justified by the facts. Appendices I and III have already been referred to. Appendix II gives a selection of material specifications, in which those familiar with the subject will recognise the admirable judgment with which the selection has been made, an apparently easy but in reality a very difficult matter.

The mechanical production of the book is excellent, the only mistake which has come to the reviewer's knowledge is the failure of the square root sign on page 218 to extend over the whole expression.

The authors have made a welcome effort to write in a good English style, and have avoided the offensive slovenliness which handicaps so many engineering writers. In conclusion, we offer our appreciation of a book marked by the competence and the conscientiousness of its authors.

Diesel Engine Design. By H. F. P. PURDAY, B.Sc., A.C.G.I. London: Constable and Co. [Price 21s. 3d. net.]

Now that the sale and distribution of oil fuel has been organised in every quarter of the world, and the price in many centres compares very favourably with that for coal, the Diesel oil engine is coming rapidly into its own. The opinion, quite generally held, is that this favourable ratio of price is neither a temporary nor a transitory state, but that, if anything, may well move in the direction of favouring more strongly the claims of liquid fuel as an economical source of power.

One disadvantage from which every innovation must inevitably suffer is misunderstanding and lack of knowledge of the new first principles involved. Those who have pioneered the Diesel oil engine will agree as to the difficulties met with being generally the outcome of insufficient knowledge. There is no royal road to the desired position of establishing that full confidence which only comes from actual experience in commercially successful application. Good text books undoubtedly lessen the necessary experimental period, making short cuts possible, and assisting to obviate the failures which have such a disastrous effect in retarding progress of application with any new machine.

The literature on the subject of Diesel engines up to date, with one, or perhaps two exceptions, has not been of such a nature as to give a really comprehensive insight into the many problems concerned with this prime mover. The large number of intricate questions may be indeed one of the reasons why this engine commands so many enthusiastic students and advocates. They will do well to study the work under review which forms a contribution of merit to the small number of good books on this subject. It cannot be said that this volume, comprehensive although it may be in comparison with some of the earlier efforts, really covers more than a fraction of what is undoubtedly a vast field. To some extent the scope is limited by the definition given of the Diesel cycle on page 2, where injection of the fuel into the cylinder by a blast of compressed air is stated as one of the essential features. During the war period, when this book was prepared, it was not possible to deal with the alternative method of injection by pressure alone, which was almost exclusively used by the British Navy, but it is not agreed that so-called "solid injection" engines are

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[1] Euler, "Sur la Force des Colonnes," *Mem. de l'Acad. de Berlin*, 1759.
[2] Clerk Maxwell, *Phil. Mag.*, 1864.
[3] Castigliano, "Equilibrium of an Elastic System," Turin, 1879.
[4] Clapeyron, "Calcul d'une Poutre Elastique, &c.," *Comptes Rendus*, 1857.
[5] Manderla, *Foerster's Allgemeine Bauzeitung*, 1880 (see also Johnson Bryan and Tourneaure, "Modern Framed Structures," Part II, page 509, 1917).
[6] Perry, *Phil. Mag.*, March, 1892.
[7] Morley, *Phil. Mag.*, June, 1908.
[8] Low, *Journ. Roy. Aer. Soc.*, April, 1914.
[9] Booth and Bolas, *Admiralty Confidential Mem.* (Air Dept.), April, 1915.
[10] Berry, *Admiralty Confidential Mem.* (Air Dept.), July, 1916 (see also collected results in *Trans. Roy. Aer. Soc.*, No. 1, 1919).
[11] Cowley and Levy, *Proc. Royal Soc.*, January, 1917.
[12] Filon, British Associa ion Report, 1919.
[13] Technische Berichte h.v.d., Flugzeugmeisterei Charlottenburg, August, 1918.
[14] Webb, Advisory Committee for Aeronautics, R. and M. 343,363 (see also Roy. Air Soc. Reprints, and *cf.* Blasius, Tech. Berichte, August, 1918.
[15] Southwell, *Phil. Trans. Roy. Soc.*, vol. ccxiii, Ser. A.
[16] Martin, ENGINEERING, "Statically Indeterminate Structures, 1895.
[17] Hiroi, "Statically Indeterminate Stresses."
[18] Church, "Mechanics of Internal Work, &c.," 1910.
[19] Andrews, "Elastic Stresses in Structures," 1919 (a translation of Castigliano's book referred to above).

ruled out of classification with the normal design engines. Much can be said for and against each method, and only experience with all types of oil fuel can give the final decision. Both systems will be developed considerably within the next few years.

Another controversial point is the relative merits of the two cycles, the four-stroke and the two-stroke. The honours up to the present have laid with the earlier, more highly developed and conservative four-stroke cycle. Progress has been made with the two-stroke cycle within recent years, and since the termination of the war a very considerable amount of intensive experimental work lies to the credit of British designers and constructors, which, it is hoped, will be brought to fruition at an early date, and will be duly recorded. In Mr. Purday's book, as is only natural, the four-stroke cycle is dealt with in much greater detail than the two cycle, and the author is happier in the sphere of design of relatively small-powered four-cycle engines than with large engines or two-cycle engines. In this last connection certain statements made are hardly correct. The reason for the higher compression pressures (page 3) necessary with two-cycle engines is the loss of volumetric efficiency at reduced speeds due to scavenging air passing out through the exhaust ports. To counteract this, in order to give a sufficient compression pressure at reduced speeds, a small compression space must be designed for, resulting in high compressions at full speed. This point was fully dealt with in ENGINEERING, June 28, 1918, pages 727 and 728. Again, such improvements have been made in scavenging efficiency that, with the latest designs, the ratio of scavenging pump to cylinder volume is now generally less than the 1·8, quoted on page 10, in the best examples reduced below the 1·4 of earlier practice. Two-cycle engines have also been improved in respect that they do not now require the large increase of compressor capacity at one time desirable for the injection of the much larger quantities of fuel consumed per brake horse-power hour (Chapter XII, page 245).

The best sections of the book are those in which mathematical expressions are evolved to equate conditions set down in a large number of cases with most commendable clarity and completeness. More particularly we would refer in this connection to Chapter III. Thermal Efficiency; Chapter IV. The Principle of Similitude; Chapter VI. Flywheels. In Chapter IV a considerable amount of valuable data and reference tables are given.

No type of mechanism, machine or engine demands more intensive thought in theory and in its design, and more scrupulous regard to practical considerations than the Diesel engine. This book is more satisfactory when dealing with the former aspect than in regard to the many practical issues of equal importance. We are in full accord with the view that steam-engine practice and precedent should only be followed by Diesel designers when it is certain that a parallel case arises, but needless to remark, successful steam-engine practice should always be carefully studied, although not necessarily followed, for Diesel work.

At the present time the greatest interest no doubt centres in the application of the Diesel engine to various types of merchant craft, and exception may be taken to the attitude of the author that it is quite simple to convert a satisfactory land type of Diesel engine to marine propulsion. It is probably the case that many of the most successful land Diesel engines are suitable with small alteration for application to this particular duty, but if the peculiar circumstances attendant upon marine propulsion are not fully appreciated and provided for, certainty of achieving the best success cannot be guaranteed. The record of performance at sea of the Diesel oil engine is such that the greatest possible care should be taken at the present time to ensure that success is the only possible outcome.

Marine work is only touched upon in this volume in distinction to the many excellent tables of data illustrating the leading characteristics of land engines of moderate powers of one, two, three, four and six cylinders. Piston cooling, for instance, which is a subject of the very highest importance with engines of high powers per cylinder of both cycles, is only briefly dealt with.

The illustrations, although reproduced to a small scale, are numerous (271 in 295 pages) and serve well to explain the text. The inclusion of a number of plates to illustrate the best-known types of both land and marine engines would have been an asset. The illustration of a detail of construction, without representation of its function in conjunction with adjacent mechanism cannot be of such assistance to designers and students as an illustration giving the complete design. The price of the volume—21*s.*—is, however, moderate, and probably prevents the inclusion of such plates.

A feature of this text book, most highly to be commended, is the inclusion at the end of each chapter of a bibliography of publications, papers and periodicals from which Mr. Purday wishes generally to acknowledge having received information and assistance.

BOOKS RECEIVED.

Proceedings of the British Foundrymen's Association, 1917–18. London: *The Foundry Trade Journal and Pattern Maker*, Bessemer House, Adelphi, Strand, W.C. 2.

The Engineering Draughtsman. By E. ROWARTH, A.M.I.E.E. London: Methuen and Co., Limited. [Price 10*s.* 6*d.* net.]

The Petroleum Handbook. By STEPHEN O. ANDROS, A.B., B.Sc., E.M. Chicago: Shaw Publishing Company, 910, South Michigan-avenue. [Price 2 dols.]

Glass Manufacture. By WALTER ROSENHAIN, B.A., D.Sc., F.R.S. Second edition, largely re-written. London: Constable and Co., Limited. [Price 12*s.* 6*d.* net.]

Labour Difficulties and Suggested Solutions. By W. J. DEELEY, B.A. Second (enlarged) edition. London: Benn Brothers and Co. [Price 10*s.* 6*d.* net.]

All About Anthracite. The World's Premier Coal. By A. LEONARD SUMMERS. London: Technical Publishing Company, Limited, 1, Gough-square, Fleet-street, E.C. 4. [Price 8*s.* 6*d.* net.]

The Motor Mechanics' Handbook. A Manual for Motor Vehicle Owners, Garage Proprietors and Mechanics. By GEORGE W. WATSON, M.I.Mech.E., M.I.A.E., and F. HERON ROGERS, M.I.Mech.E. London: Cassell and Co., Limited. [Price 3*s.* 6*d.* net.]

The Colliery Manager's Pocket Book Almanac and Diary, 1920. Edited by J. VINCENT ELSDEN, D.Sc.(Lond.), F.G.S., and HUBERT GREENWELL, F.S.S., Assoc. M.I.M.E. London: *Colliery Guardian* Company, Limited, 30 and 31, Furnival-street, E.C. 4.

Screw Propellers and Estimation of Power for Propellers of Ships; also Airship Propellers. By Rear-Admiral CHARLES W. DYSON, U.S.N. Vol. I. Text. Vol. II. Atlas. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 34*s.* 6*d.* net.]

Le Barrage du Neuquen et les Irrigations dans la Vallée du Rio Negros. Par F. A. SOLDANO. Buenos Ayres: Imprémérie et Editions "Coni."

The Institution of Gas Engineers. Transactions 1918–19. Edited by WALTER T. DUNN, F.C.I.S. London: Offices of the Institution, 39, Victoria-street, S.W. 1, and E. and F. N. Spon, Limited.

Memoirs of the College of Engineering. Kyoto Imperial University. Vol. II, Nos. 1, 2, 3, 4, 1918. Kyoto: Japan. Published by the University.

An Algebra for Engineering Students. By GEORGE S. EASTWOOD, B.Sc.(Hons. Lond.), and JOHN R. FIELDEN, B.Sc.(Vict.). London: Edward Arnold. [Price 7*s.* 6*d.* net.]

The Dyeing Industry. Being a Third Edition of Dyeing in Germany and America. By S. H. HIGGINS, M.Sc. London: Longmans, Green and Co. [Price 8*s.* 6*d.* net.]

The Coal Consumption of Power Plants and Bonuses for Coal Saving. By ROBERT H. PARSONS, M.Can.Soc.C.E., Assoc.M.Inst.C.E. London: *Electrical Review*, Limited, 4, Ludgate Hill, E.C. 4. [Price 1*s.* net.]

Department of Commerce, Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1918. Washington: Government Printing Office. [Price 50 cents.]

Department of Commerce. Bureau of Foreign and Domestic Commerce. Monthly Summary of Foreign Commerce of the United States. May, 1919. Washington: Government Printing Office. [Price 15 cents.]

United States Bureau of Labour Statistics. Bulletins: No. 245. *Union Scale of Wages and Hours of Labour, May* 15, 1917. [Price 25 cents.] No. 248. *Proceedings of the International Association of Industrial Accident Boards and Commissions, Boston, August* 21 *to* 25, 1917. [Price 30 cents.] No. 249. *Industrial Health and Efficiency, Final Report of the British Health of Munition Workers' Committee.* [Price 35 cents.] Washington: Government Printing Office.

United States Coast and Geodetic Survey. Serial Nos. 105. *Terrestrial Magnetism, Results of Magnetic Observations made in* 1918. By DANIEL L. HAZARD. [Price 5 cents.] No. 109. *Important Publications of the United States Coast and Geodetic Survey, appearing since January* 1, 1914. Washington: Government Printing Office.

Railway Statistics of the United States of America for the Year ended December 31, 1918, *compared with the Official Reports for* 1917 *and Recent Statistics of Foreign Railways.* Prepared by SLASON THOMPSON, Bureau of Railway News and Statistics, Chicago, Illinois.

A STEAM ALIGNMENT DIAGRAM.

By D. HALTON THOMSON, M.A.(Cantab.), A.M.I.Mech.E.

THE advantages of solving steam problems by graphical methods are not far to seek. Many of the expressions representing the relations between steam properties are so complex in form that their numerical calculation—particularly in the superheat region—is both tedious and liable to error. Even with tables at hand this difficulty is only partially overcome, because interpolation between the tabulated values is seldom avoided. It is not surprising, therefore, that steam diagrams, especially for preliminary work, are in common use, not only on account of the saving of time and decrease in the risk of miscalculation, but because their employment appeals to the eye and permits the effect of changing conditions to be readily followed.

The six most important properties which appear in steam calculations are pressure, volume, temperature, entropy, quality (superheat or dryness fraction) and total heat, and in practice it is customary to represent two of them as cartesian co-ordinates and to show two others as families of lines referred to the primary rectangular net-work. A well-known example is the Mollier diagram, in which total heat and entropy are the co-ordinates, with lines of constant pressure and constant quality referred thereto. Theoretically, lines of constant volume and constant temperature could be drawn on the same diagram, but the network of lines, already sufficiently intervolved, would thereby become unreadable and impracticable. So long as the common cartesian system only is employed, the sole remedy is to construct another diagram with a different selection of properties. In short, to provide a complete graphical solution for all six properties, two separate cartesian diagrams are necessary.

By applying the alignment principle, however, a complete solution for all six variables can be provided on a single diagram, at the same time avoiding the complex network of lines of the ordinary cartesian system. It is, in fact, possible to provide an alternative means of obtaining all the data usually found on the Mollier total-heat-entropy diagram, together with some additional information to be detailed later. It is not suggested that tables and numerical calculations can be superseded—for these will always be necessary in close work—but it is believed that the steam alignment diagram, here described, has some advantages where graphical methods are considered sufficiently accurate for the purpose in view. Its primary object is to afford a means of determining the principal properties of steam, whether wet, dry saturated, superheated or supersaturated, and of tracing the effect of changes of state with special reference to expansion in steam turbines.

NOTATION.

Pound-Fahrenheit units are employed throughout, and the notation used is as follows:—

p = absolute pressure, in pounds per square inch.
V = specific volume, in cubic feet per pound.
T = absolute temperature, in degrees Fahrenheit.
t = actual temperature in degrees Fahrenheit.
t' = superheat in degrees Fahrenheit.
Φ = entropy per pound.
H = total heat per pound in British thermal units.
q = dryness fraction of wet steam.
v = velocity of steam in feet per second.
The suffix s refers to dry saturated steam.
The suffix q refers to wet steam.
η = hydraulic efficiency.

BASIS OF DIAGRAM.

The principal part of the diagram is based on the equations for the properties of steam propounded by Professor H. L. Callendar, F.R.S., which are summarised in the earlier pages of "The Callendar Steam Tables." These not only agree very closely with experiment, but, being derived from a single characteristic equation and developed therefrom with the aid of general thermodynamical principles, are mathematically consistent; they avoid, therefore, the numerical discrepancies which are apt to appear when the older empirical formulas are used.

Although a comparison with standard forms shows that it is possible to develop alignment diagrams for certain of the Callendar equations,

taken separately, as has actually been done by Professor W. J. Goudie,* other equations on account of their form are not amenable to such treatment. It might, therefore, appear that a combined alignment diagram, comprehending all the more important steam properties was not a feasible proposition. Although this is true in a strict algebraical sense, a reference to one of the first principles of projective geometry—the principle of duality—indicates a graphical method by which a very close solution may be attained.

It may be shown† that if any group of correlated variables can be represented by a diagram consisting wholly of families of intersecting straight lines (*e.g.*, common cartesian co-ordinates and straight lines referred thereto), this diagram may be transformed to the alignment system in such a way that any three (or more) straight lines passing through the same point on the cartesian system correspond to three (or more) points lying on a straight line on the alignment system. This "dualistic transformation" is possible without necessarily knowing the form of the algebraical equation connecting the variables.

To apply this principle, therefore, the first step is to produce a cartesian diagram consisting wholly of straight lines. The Mollier total-heat-entropy diagram, the Callendar total-heat-pressure diagram, and others, since they all include families of curved lines, are not directly suitable for the above transformation.

Now, the form of the two Callendar equations:—

$$V = \frac{1{\cdot}2464\,(H - 835{\cdot}2)}{p} + {\cdot}0123 \quad . \quad . \quad (1)$$

$$p\,(V - {\cdot}01602) = \text{constant} \quad . \quad . \quad . \quad (2)$$

suggests that the functional co-ordinates log. p and log. $(H - 835{\cdot}2)$ (instead of log. p and H, as in the Callendar diagram) might be adopted. A diagram with these co-ordinates is shown in outline in Fig. 1, where the p and H lines (forming the primary rectangular network) and the Φ and V lines are perfectly straight, while the t'-, q-, H_q- and V_q-lines are very nearly straight. The curvature of these latter lines, however, is so slight that within the field of the diagram actually used they may be regarded as straight, and the errors in the corresponding alignment diagram, keeping in mind the limitations of all graphical processes, so small as to be negligible. The degree of error may be gauged by comparing the readings obtained from the slightly curved lines in Fig. 1 with those from the straight lines which most nearly correspond thereto within the practical range of values.

The alignment diagram under discussion (see Fig. 10, page 304) was constructed, partly with the aid of equations (1) and (2), and partly by a graphical process based on the above principle of transformation, the whole being checked from the Callendar steam tables. The vertical lines representing hydraulic efficiency, the "Wilson point" (lower limit of complete supersaturation) and the reheat factors used in the examples are derived from the equations and tables developed in H. M. Martin's "New Theory of the Steam Turbine."* Details of construction are given in the appendix.

The reciprocal relation between the two types of diagram will be noted; lines in the one diagram become points in the other, and *vice versa*, *e.g.*, "state points," "condition lines," and "saturation line" in the cartesian diagram are represented by "state lines," "condition points" and "saturation point" in the alignment diagram.

Steam Properties.

The various properties are represented on the diagram by axes with figured scales. The graduations of the scales and their relative magnitude and position are such that when any straight line is drawn across the diagram, the points of intersection on the scales indicate simultaneous values of the properties. Such a line thus represents steam in any one physical state, and may be termed a "state line." This state line need not necessarily be drawn; it may be represented by laying in the required position any straight edge or a transparent celluloid strip with a straight line scratched on the underside. The latter has the advantage that it permits all the graduations on the scales to be kept in view.

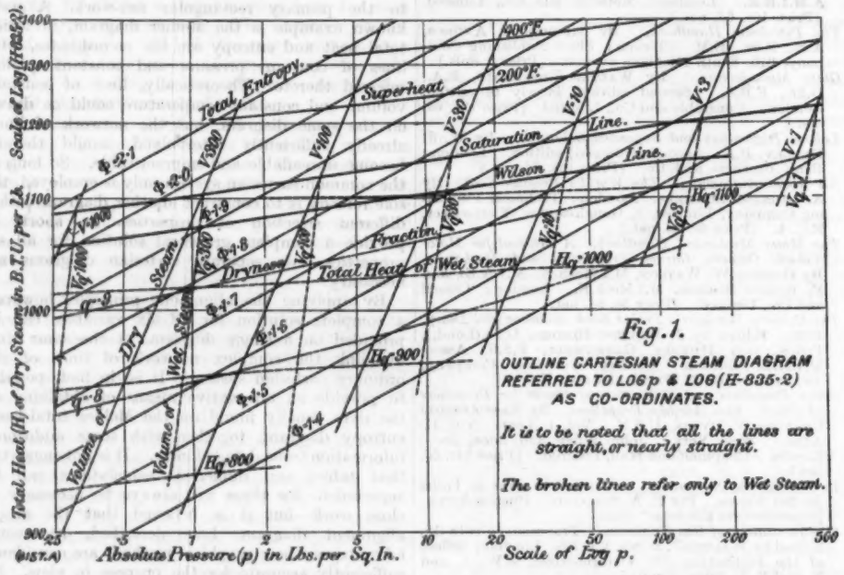


Fig. 1.

OUTLINE CARTESIAN STEAM DIAGRAM REFERRED TO LOG p & LOG (H-835·2) AS CO-ORDINATES.

It is to be noted that all the lines are straight, or nearly straight.

The broken lines refer only to Wet Steam.

The scales which are to be read together depend on the quality of the steam, and are tabulated on the diagram (Fig. 10, page 304).

Wet Steam.—The state line passes below the "saturation point" and the values of the properties are read on scales marked H_q, q, Φ, V_q, p and t_s.

Dry Saturated Steam.—The state line passes through the "saturation point" and the values of the properties are read on any of the scales. It will be found that the readings on the H- and H_q-scales, and on the V- and V_q-scales are identical.

Superheated Steam.—The state line passes above the "saturation point" and the values of the properties are read on scales marked H, t', Φ, V and p. The actual temperature is obtained by the sum of readings on scales t_s and t'.

Supersaturated Steam.—The state line passes below the "saturation point" and the values of the properties are read on scales marked H, Φ, V and p. The temperature is not given. The lower limit of complete supersaturation is determined by state lines through the "Wilson point," corresponding to the "Wilson line" on Martin's diagram.*

Example 1.—Given, steam at pressure $p = 3$ lb. per square inch absolute and quality $q = 0{\cdot}88$. Required, the other principal properties.

A state line intersecting the p-scale at 3 and the q-scale at 0·88 passes through the H_q scale at 1,000, the Φ scale at 1·685, the V_q scale at 104, and the t_s scale at 142.

Example 2.—Given, steam at pressure $p = 160$ lb. per square inch absolute, and temperature = 590 deg. F. Required, the other principal properties.

From the reading on the t_s-scale opposite $p = 160$, the saturation temperature is 363. The superheat, therefore, is $t' = 590 - 363 = 227$. A state line intersecting the p scale at 160 and the t' scale at 227 passes through the H-scale at 1,324, the Φ scale at 1·705 and the V-scale at 3·84.

Changes of State.

The initial and final conditions of a change of state are represented by two state lines intersecting at some point on the diagram. This point may be termed the "condition point." In the case of throttling, when no external work is done, the condition point lies on the H- or H_q-scale (according to the quality); in an adiabatic change, when no losses occur, it lies on the Φ scale; in any change involving partial loss by friction, it is situated at some point between these scales.

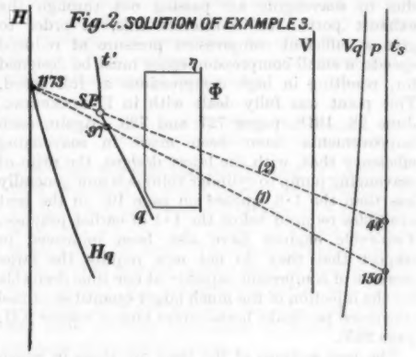


Fig. 2. SOLUTION OF EXAMPLE 3.

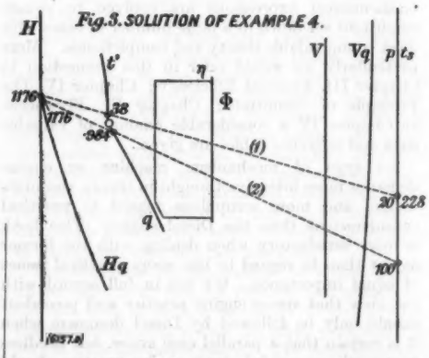


Fig. 3. SOLUTION OF EXAMPLE 4.

The condition point may be regarded as a fixed hinge-point, on which is pivoted a state line representing intermediate conditions. As the steam passes from a dry to wet state, the readings for total heat and specific volume indicated by the moving state line change over from the H- and V- scales to the H_q and V_q-scales, respectively, and *vice versa*. Where there are frictional losses the condition point is strictly fixed only in the superheat and supersaturation portion of the expansion in a multi-stage turbine; in other cases the hinge-point moves slightly during a change of state, because the corresponding condition line on the cartesian diagram, (Fig. 1), is not quite straight. The effect of the variation, however, is so small that it may often be neglected.

The heat-drop is given by the difference between the readings at the intersections of two state lines

* W. J. Goudie, "Some Graphical Methods of Determining the Properties of Superheated, Supersaturated and Wet Steam." Institution of Engineers and Shipbuilders in Scotland, April 23, 1918.

† M. d'Ocagne, "Calcul Graphique et Nomographie." Second edition, page 225.

* ENGINEERING, 1918, vol. cvi. Instalments commence on pages 1, 53, 107, 161, 189 and 245. The article has been republished by ENGINEERING in pamphlet form.

* ENGINEERING, vol. cvi, Plate I.

on the H or H_q scale (according to the quality). If the difference represents the drop in one stage of a turbine, the corresponding velocity of the steam is obtained by the reading opposite to that difference on the auxiliary scale at the foot of the diagram.

Example 3 (*Fig.* 2).—Given, steam at pressure $p = 150$ lb. per square inch absolute, with dryness fraction $q = 0{\cdot}97$; it is passed through a reducing valve. Required, the pressure at which it must be set to discharge dry saturated steam.

State line (1), representing the initial state, passes through $p = 150$ and $q = 0{\cdot}97$, giving $H_q = 1{,}173$. Since no work is done and H_q remains constant, state line (2), representing the final state, passes through $H_q = 1{,}173$ and the saturation point, giving the required pressure $p = 44$.

Example 4 (*Fig.* 3).—Given, steam at pressure $p = 100$ lb. per square inch absolute; it is passed through a throttling calorimeter, the final pressure being $p = 20$ lb. per square inch absolute, and the temperature 266 deg. F. Required, the initial quality.

From the reading on the t_s scale opposite $p = 20$, the saturation temperature is 228. The final superheat, therefore, is $t' = 266 - 228 = 38$. State-line (1), representing the final state, passes through $p = 20$ and $t' = 38$, giving $H = 1{,}176$. State-line (2), representing the initial state, passes through $H_q = 1{,}176$ (note the change from the H to the H_q scale, since it is evident that the steam was originally wet) and $p = 100$, giving the required initial quality (dryness fraction) $q = 0{\cdot}984$.

Example 5 (*Fig.* 4).—Given, steam at pressure $p = 160$ lb. per square inch absolute, and superheated 50 deg. F.; it expands in thermal equilibrium through a nozzle to pressure $p = 3$ lb. per square inch absolute. Required, the initial and final specific volumes, final quality, heat drop and velocity, assuming (*a*) adiabatic expansion, (*b*) a frictional loss of 12 per cent.

Case (*a*).—State line (1), representing the initial state, passes through $p = 160$ and $t' = 50$, giving $H = 1{,}229$, $\Phi = 1{\cdot}603$ and $V = 3{\cdot}05$. Since entropy is constant, state line (2), representing the final state, passes through $p = 3$ and $\Phi = 1{\cdot}603$, giving $H_q = 953$, $q = 0{\cdot}832$ and $V_q = 98$. The adiabatic heat-drop $= 1{,}229 - 953 = 276$. The velocity on the auxiliary scale opposite to heat-drop $= 276$ is $v = 3{,}720$.

Case (*b*).—State lines (1) and (2) and the adiabatic heat-drop are first determined as in case (*a*). The actual heat-drop $= 276 \times 0{\cdot}88 = 243$, whence the actual final total heat $= 1{,}229 - 243 = 986$. State-line (3), therefore, representing the actual final state, passes through $H_q = 986$ and $p = 3$, giving $q = 0{\cdot}865$ and $V_q = 102$. The velocity on the auxiliary scale opposite to heat drop $= 243$, is $v = 3{,}480$.

In either case the condition point for the expansion is at the intersection of the initial and final state lines.

Application to Steam Turbines.

Single-Stage Turbines.—The condition point, net heat-drop and velocity are determined as in Example 5 (*b*) above.

Few-Stage Turbines.—If the hydraulic efficiency and re-heat factor are known or assumed, these may be treated by calculating the cumulative heat-drop for each stage, and repeating for each the operation indicated in Example 5 (*b*). It will be found that the condition point moves slightly at each stage. A more direct procedure, which gives almost identical results, is to determine a fixed condition point for the whole expansion, as in the following example.

Example 6 (*Fig.* 5).—Given, a four-stage turbine in which steam expands in thermal equilibrium from initial pressure $p = 200$ lb. per square inch absolute and superheat 100 deg. F., to final pressure $p = 1{\cdot}5$ lb. per square inch absolute; the stage efficiency is 0·65 and the reheat factor 1·045. Required, the pressure, specific volume and quality at the end of each stage, assuming that the total net heat-drop is divided equally between the stages.

State line (1), representing the initial state, passes through $p = 200$ and $t' = 100$, giving $H = 1{,}263$, $\Phi = 1{\cdot}618$ and $V = 2{\cdot}65$. State line (6), representing the final state after adiabatic expansion, passes through $p = 1{\cdot}5$ and $\Phi = 1{\cdot}618$, giving $H_q = 924$. The adiabatic heat-drop, therefore, is $1{,}263 - 924 = 339$. The actual net heat-drop $= 339 \times 0{\cdot}65 \times 1{\cdot}045 = 230$; whence the actual final total heat $= 1{,}263 - 230 = 1{,}033$. State line (5), therefore, representing the actual final state, passes through $H_q = 1{,}033$ and $p = 1{\cdot}5$, giving $q = 0{\cdot}925$ and $V_q = 210$, its intersection with state line (1) being the condition point for the whole expansion. The properties of the steam at each stage are obtained by dividing the heat-drop on the H and H_q scales, into four equal parts and laying a state line through each point thus determined and the condition point.

The properties at each stage are tabulated below:

State-line.	Absolute Pressure.	Specific Volume.	Quality.	Total Heat.	Heat-Drop.
(1)	200·0	2·65	100 deg. Sup.	1,263·0	57·5
(2)	74·0	6·2	40 deg. Sup.	1,205·5	57·5
(3)	24·0	16·8	0·987	1,148·0	57·5
(4)	6·8	53·0	0·955	1,090·5	57·5
(5)	1·5	210·0	0·925	1,033·0	
			Total heat-drop		230·0

Multi-Stage Turbines.—The procedure is divided into two parts; the first applies to expansion, above the saturation point if wet steam in thermal equilibrium is assumed below, or above the Wilson point if supersaturation is assumed to take place down to that point; the second applies to the remainder of the expansion.

(1) For the superheated and supersaturated part of the expansion the condition point lies on the vertical from the η scale, corresponding to the known hydraulic efficiency. The intersection of this vertical with the initial state line thus determines the condition point without any knowledge of the reheat factor. The final state line is drawn through this point and the net heat-drop is given directly by the difference between the initial and final readings on the H-scale. It is to be noted that the η scale on the diagram applies only to the superheated and supersaturated part of the expansion in a multi-stage turbine.

(2) For the remainder of the expansion the condition point and net heat-drop are calculated in a manner similar to that for one stage in a few-stage turbine, *i.e.*, the adiabatic heat-drop is first found and an adjustment then made by means of the given hydraulic efficiency and a reheat factor.

Example 7.—Given, a multi-stage turbine in which the stop-valve pressure is 195 lb. per square inch absolute, and the superheat 150 deg. F.; the initial pressure below the governor is 180 lb. per square inch absolute, and the steam is expanded down to 1 lb. per square inch absolute; the hydraulic efficiency $\eta = 0{\cdot}7$. Required, the heat usefully employed and the volume change during expansion in the four following cases:—

(*a*) Thermal equilibrium is maintained throughout; reheat factor below saturation point, 1·030.

Fig.4. SOLUTION OF EXAMPLE 5, CASES (a) & (b).

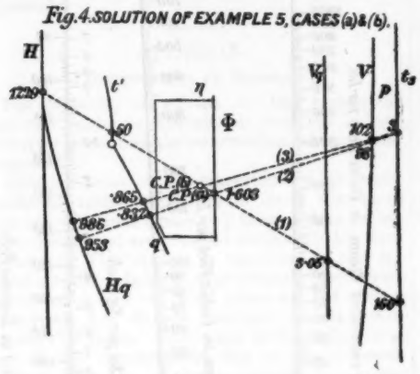


Fig.6. SOLUTION OF EXAMPLE 7, CASE (a).

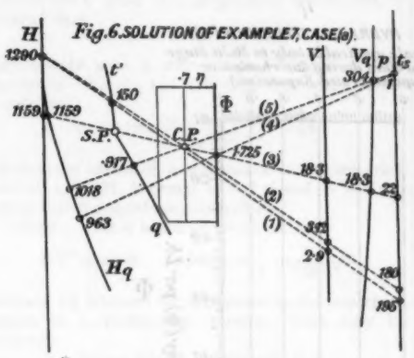


Fig.8. SOLUTION OF EXAMPLE 7, CASE (c).

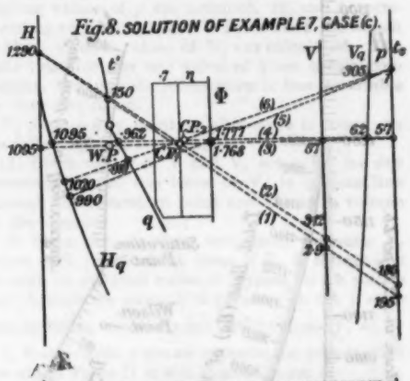


Fig.5. SOLUTION OF EXAMPLE 6.

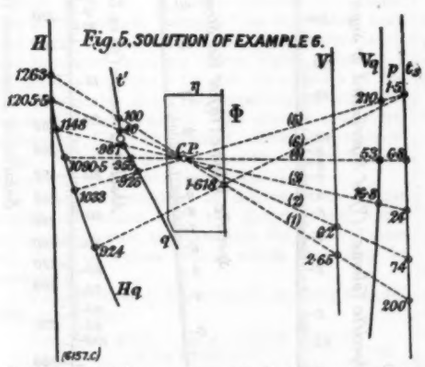


Fig.7. SOLUTION OF EXAMPLE 7, CASE (b).

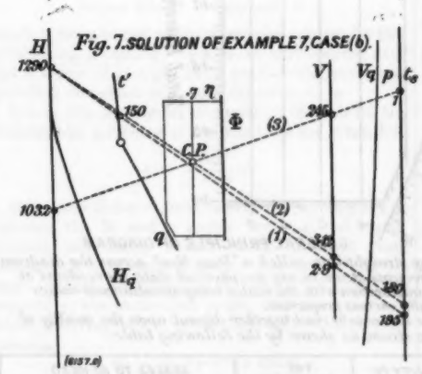
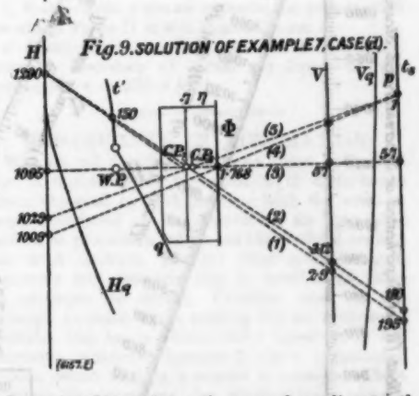


Fig.9. SOLUTION OF EXAMPLE 7, CASE (d).



(*b*) No condensation takes place throughout the expansion (value of reheat factor not required).

(*c*) No condensation takes place above the Wilson point (lower limit of supersaturation), but thermal equilibrium completely re-established below; reheat factor below Wilson point, 1·016.

(*d*) No condensation takes place above the Wilson point, but below the steam expands according to Martin's theory i.e., that thermal equilibrium is only partially re-established due to the conversion into heat of the energy liberated on condensation not being instantaneous; equivalent reheat factor below Wilson point, 1·094.*

heat drop down to the saturation point = 1,290 — 1,159 = 131. Below the saturation point, state line (4), representing the final state of wet steam after adiabatic expansion, passes through $\Phi = 1{\cdot}725$ and $p = 1$, giving $H_q = 963$. The adiabatic heat-drop, therefore, is 1,159 — 963 = 196. The actual heat-drop = 196 × 0·7 × 1·030 = 141; whence the actual final total heat = 1,159 — 141 = 1,018. State line (5), therefore, representing the actual final state passes through $H_q = 1{,}018$ and $p = 1$, giving $q = 0{\cdot}917$ and $V_q = 304$, its intersection with state line (3), being the condition point for the steam below the saturation point. It so happens

point, giving H = 1,095, $\Phi = 1{\cdot}768$, V = 57 and $p = 5{\cdot}7$. The net heat-drop down to the Wilson point is 1,290 — 1,095 = 195. On regaining thermal equilibrium the total heat and pressure are unchanged, but the total heat reading crosses to the H_q scale; state line (4), therefore, passes through $H_q = 1{,}095$ and $p = 5{\cdot}7$, giving $q = 0{\cdot}962$, $\Phi = 1{\cdot}777$ and $V_q = 62$. Below the Wilson point, state line (5) representing the final state of wet steam after adiabatic expansion, passes through $\Phi = 1{\cdot}777$ and $p = 1$, giving $H_q = 990$. The adiabatic heat drop, therefore, is 1,095 — 990 = 105. The actual heat drop = 105 × 0·7 × 1·016 = 75;

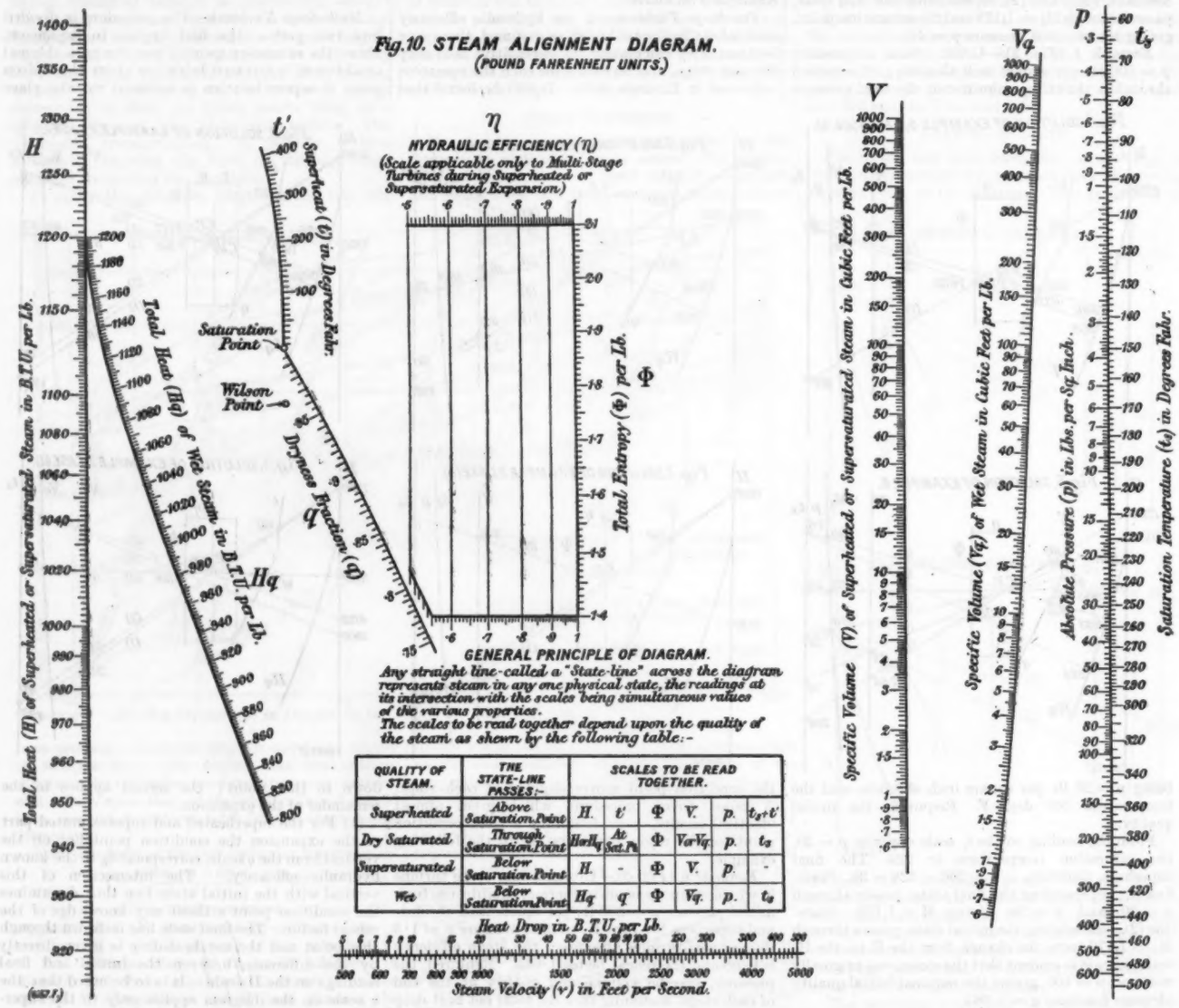


Fig.10. STEAM ALIGNMENT DIAGRAM.
(POUND FAHRENHEIT UNITS.)
H
Total Heat (H) of Superheated or Superaturated Steam in B.T.U. per Lb.
t'
Superheat (t') in Degrees Fahr.
Saturation Point
Wilson Point
Dryness Fraction (q)
Hq
Total Heat (Hq) of Wet Steam in B.T.U. per Lb.
η
HYDRAULIC EFFICIENCY (η)
(Scale applicable only to Multi-Stage Turbines during Superheated or Supersaturated Expansion)
Φ
Total Entropy (Φ) per Lb.
GENERAL PRINCIPLE OF DIAGRAM.
Any straight line called a "State-line" across the diagram represents steam in any one physical state, the readings at its intersection with the scales being simultaneous values of the various properties.
The scales to be read together depend upon the quality of the steam as shown by the following table:-
V
Specific Volume (V) of Superheated or Supersaturated Steam in Cubic Feet per Lb.
Vq
Specific Volume (Vq) of Wet Steam in Cubic Feet per Lb.
p
Absolute Pressure (p) in Lbs. per Sq. Inch.
ts
Saturation Temperature (ts) in Degrees Fahr.
Heat Drop in B.T.U. per Lb.
Steam Velocity (v) in Feet per Second.

QUALITY OF STEAM.	THE STATE-LINE PASSES:-	SCALES TO BE READ TOGETHER.					
Superheated	Above Saturation Point	H.	t'	Φ	V.	p.	$t_s + t'$
Dry Saturated	Through Saturation Point	H or H_q	At Sat. Pt.	Φ	V or V_q	p.	t_s
Supersaturated	Below Saturation Point	H.	-	Φ	V.	p.	-
Wet	Below Saturation Point	H_q	q	Φ	V_q.	p.	t_s

Case (*a*) (*Fig.* 6).—State line (1), representing steam at the stop valve, passes through $p = 195$ and $t' = 150$, giving H = 1,290 and V = 2·9. Since no work is done in the governor and H remains constant, state line (2), representing steam below the governor, passes through H = 1,290 and $p = 180$, giving V = 3·12, its intersection with the vertical through $p = 0{\cdot}7$, being the condition point for the steam so long as it is dry. State line (3), representing dry saturated steam, passes through this point and the saturation point, giving H_s = 1,159, $\Phi_s = 1{\cdot}725$, $V_s = 18{\cdot}3$ and $p_s = 22$. The net

that in this case the two condition points are practically in the same position.

The total net heat-drop from the initial state = 131 + 141 = 272.

Case (*b*) (*Fig.* 7).—State lines (1) and (2) and the first condition point are found as in Case (*a*). Since the steam is assumed to be first superheated and then supersaturated down to the terminal pressure, this condition point applies throughout the expansion. State line (3), therefore, representing the actual final state, passes through the condition point and $p = 1$, giving H = 1,032 and V = 245. The total net heat-drop from the initial state = 1,290 — 1,032 = 258.

Case (*c*) (*Fig.* 8).—State lines (1) and (2) and the first condition point are found as in Case (*a*) State line (3), representing the lower limit of supersaturation, passes through this point and the Wilson

whence the actual final total heat = 1,095 — 75 = 1,020. State line (6), therefore, representing the actual final state, passes through $H_q = 1{,}020$ and $p = 1$, giving $q = 0{\cdot}919$ and $V_q = 305$, its intersection with state line (4) being the condition point for the steam below the Wilson point. The total net heat-drop from the initial state = 195 + 75 = 270.

Case (*d*) (*Fig.* 9).—State lines (1), (2) and (3), the first condition point and the net heat-drop down to the Wilson point are found as in Case (*c*). Below the Wilson point state line (4), representing the final state of supersaturated steam after adiabatic expansion, passes through $\Phi = 1{\cdot}768$ and $p = 1$, giving H = 1,009. The adiabatic heat-drop, therefore, is 1,095 — 1,009 = 86. The actual heat-drop = 86 × 0·7 × 1·094 = 66; whence the actual final total heat = 1,095 — 66 = 1,029. State

* In a recent leading article entitled "Undercooled Steam" in ENGINEERING, vol. cviii, pp. 843–4, it is suggested that expansion beyond the Wilson point may proceed with an initial volume smaller, and a final volume greater, than was provisionally assumed by Martin. If this is so, his values of the equivalent reheat factor will require to be modified.

line (5), therefore, representing the actual final state, passes through H = 1,029 and $p = 1$, intersecting state line (3) at the condition point for the steam below the Wilson point. The readings on the q and V_q scales do not apply in this case; Martin states that the required specific volume V_w below the Wilson point is given by:

$$V_w = 0.8\,V + 0.2\,V_g.$$

where V is the specific volume under Case (*b*) and V_g that under Case (*c*). In the present case, therefore, the final $V_w = 0{\cdot}8 \times 245 + 0{\cdot}2 \times 305 = 257$. The total net heat-drop from the initial state = 195 + 66 = 261.

It will be noted that in Cases (*a*), (*c*) and (*d*) the position of the second condition point differs but slightly from that for the dry part of the expansion; the difference, however, may be sufficient to affect readings in the total heat scales, so that the second condition point should usually be determined separately.

APPENDIX.

Construction of Diagram.

The following is written on the assumption that the reader is acquainted with the general principles governing the construction of alignment diagrams.

Although most of the properties can be represented by scales which are in strict accordance with the equations connecting them, others cannot be so treated and are obtained graphically by cross-alignment. This applies in particular to the H_q, t' and q scales. In such cases the state lines drawn to determine any one scale point are not always concurrent, *i.e.*, do not intersect at one point, although nearly so. This is due to the slight curvature of the corresponding line on the cartesian diagram (Fig. 1). A mean position is selected after giving special "weight" to those state lines most likely to occur in practice, *e.g.*, for the t'-scale state lines corresponding to the higher values of p are given preference; for the lower parts of the H_q and q scales those corresponding to the lower values of p are favoured. The error in actual use is, therefore, likely to be small. Having thus determined a number of points on a scale, the graduations are inserted by graphical interpolation.

It has been possible to deduce some simple empirical formulas from the diagram, and these are recorded below, together with the limits of error and range of values within which they may be employed.

p, V *and* H *Scales.*—Equation (1), in its logarithmic form, is written:

$$\text{Log. } (H - 835.2) - \log. p - \log. (V - 0.0123) + \log 1.2464 = 0 \quad . \quad . \quad . \quad (3)$$

This is of the general type:

$$f(u) + f(v) + f(w) = 0 \quad . \quad . \quad (4)$$

which is represented on the alignment principle by three parallel scales, for any two of which the position and units may be arbitrarily selected. Let the two outer scales correspond to the functional co-ordinates in Fig. 1; let them be 18 in.* apart and represented by:

$$u = \mu_1 \log (H - 835.2)$$
$$v = \mu_2 \log p$$

the logarithmic units being $\mu_1 = +20$ in., $\mu_2 = -5$ in. The positive sign denotes that the scale increases upwards; the negative sign that it increases downwards. The V scale is obtained either by cross-alignment, or, better by calculation. The latter shows that it is given by

$$w = +4 \log (V - 0.0123)$$

and lies between the H and p scales at a distance 3·6 in. from the latter.

Φ *Scale.*—In equation (2)

$$p\,(V - 0.01602)^{1.3} = \text{const.}$$

the right-hand side is constant only for an adiabatic change; for any other change it must be some function of the entropy. Further (V − 0·0123) in equation (1) is practically identical with (V − 0·01602) in equation (2). Eliminating V, therefore, between (1) and (2), a general equation connecting p, H and ϕ is developed,

$$\frac{(H - 835.2)^{1.3}}{p^{0.3}} = f(\Phi)$$

or, in logarithmic form,

$$1.3 \log (H - 835.2) - 0.3 \log p - f(\Phi) = 0 \quad (5)$$

This, again, is of the general type (4). By calculation the Φ scale lies on a straight line between the H and p scales already constructed and at a distance of 9·36 in. from the latter. Although its equation is unknown the scale is accurately determined by state lines between the H and p scales intersecting the predetermined axis at assumed values of Φ. Simultaneous values of p, H and Φ are found by the aid of Tables IV and VI of the Callendar Steam Tables (subsequently referred to as the Steam Tables).

From the Φ scale thus graphically determined, it is found that

$$f(\Phi) = 20 \log (\Phi + 5.4)$$

very closely over a wide range. Combining this expression with (5), the following empirical formula is obtained:

$$\Phi = 5.1265\,\frac{(H - 835.2)^{0.065}}{p^{0.015}} - 5.4$$

which gives values of Φ with an error varying from zero to ± 0·001, between $\Phi = 1{\cdot}5$ and $\Phi = 2{\cdot}1$; this covers the usual range of values.

η *Scale.*—This is based on the equation

$$P\,V^{\lambda} = \text{const.} \qquad \text{where } \lambda = \frac{1}{1 - 0.23077\,\eta}$$

deduced by Martin* for expansion in the superheat region in a multi-stage turbine. This may be written:

$$\log p + \lambda \log V - \log (\text{const.}) = 0$$

which is represented on the alignment system by two parallel log. p and log. V scales (already constructed) and a series of straight lines parallel thereto corresponding to values of λ, and therefore of η.

If x is the horizontal distance to the left of the V-scale, the positions of the verticals are given by:

$$x = \frac{2.88}{\lambda - 0.8} \text{ in.}$$

Saturation Point.—Determined by cross-alignment between the H and p scales, the required simultaneous saturation values being obtained from Table II in the Steam Tables. The state lines are very nearly concurrent. A mean position is selected as the saturation point, state lines through which give readings in accordance with the empirical formula:

$$H_s = 267.9\,p^{0.061} + 835.2$$

This gives values of H which differ from the tabulated values by amounts varying from zero to about ± 1 British thermal unit, except when p is greater than 300, in which case those obtained from the formula are too large.

Wilson Point.—Determined by cross-alignment between the H and p scales or the H and Φ scales, simultaneous values being obtained from a table in Martin's article.† The state lines are concurrent for the range of values likely to occur in practice. State lines through this point represent the lower limit of supersaturation and correspond to the formula

$$H = 233.8\,p^{0.061} + 835.2$$

which gives correct values when p is less than about 40 lb., as is usual in practice.

t' *Scale.*—Determined by cross-alignment between the H and p scales, simultaneous values of H and p for any assumed superheat being obtained by interpolation in Table IV of the Steam Tables. They may be rather more conveniently obtained from a diagram in Goudie's paper.‡ For any given superheat the state lines are nearly concurrent, except when p is less than about 20; superheats, however, seldom occur in practice below that pressure.

H_q *Scale.*—Determined by cross alignment between the p and Φ scales, the state lines intersecting to the left of the Φ scale. Simultaneous values of p and Φ_q for any assumed value of H_q are calculated from the equation:

$$H_s - H_q = T_s\,(\Phi_s - \Phi_q)$$

For any one point on the scale, a fixed value of H_q and varying values of p are assumed, H_s, T_s and Φ_s corresponding to p being found in Table II of the Steam Tables; whence values of Φ_q are calculated. The state lines for any one value of H_q are nearly concurrent, although the intersection is less favourable for low values of H_q.

It should be noted that for dry saturated steam identical scale readings of H and H_q must lie on straight lines passing through the saturation point.

q *Scale.*—Determined by cross-alignment between the H_q and p scales. Simultaneous values of H_q and p for any assumed value of q are calculated from the equation:

$$H_q = q\,H_s + (1 - q)\,(t_s - 32)$$

For any one point on the scale, a fixed value of q and varying values of p are assumed, H_s and t_s corresponding to p being found in Table II of the Steam Tables; whence values of H_q are calculated. The state lines for any one value of q are nearly concurrent, although the intersection is less favourable for very wet steam.

V_q *Scale.*—Any point on this scale is found on the following considerations:—

(1) Since values of V and V_q are equal for dry saturated steam, one locus of V_q is a state line through the saturation point and the same volume on the V scale.

(2) Since for a given saturation pressure V_q varies with q, the second locus of V_q is a state line through an assumed value of dryness on the q scale and through the saturation pressure on the p scale corresponding to the dry saturated volume $V_s = \frac{V_q}{q}$.

t_s *Scale.*—This is drawn opposite the p scale with the aid of Table II in the Steam Tables.

v *Scale.*—This auxiliary scale and the corresponding heat-drop (h) scale are based on the equation: $v = 223{\cdot}8\,h^{\frac{1}{2}}$.

MANAGEMENT IN MODERATION.

We are all familiar with the fussy individual who is notorious for the creation of disturbance unaccompanied by real progress with the work in hand, convinced of his mission as an organising genius, he propounds numerous ideas which conflict one with another, possibly tries several simultaneously and succeeds only in bewildering those he attempts to direct. Familiar, also, is the lethargic example whom nothing but an earthquake disturbs, who has a conscientious objection to any alteration whatever because it alters accustomed routine which to him is almost a religion. There is, again, the querulous type, whom nothing pleases, whose mission in life is to discover imperfection in the most flawless, who is prone to sap the good will of those around by detraction and hypercriticism, whose speciality is to view all things from an opposite, if not a hostile, standpoint.

Unobtrusive service in any station without fuss, disturbance, somnolence or carping is not perhaps so usual as it might be, but it is proof positive of capacity. Such service has dangers to the advancement of the individual, he is too much taken for granted, and often he is penalised because it is difficult to fill his place adequately. Apart from this, is it possible that industrial concerns are too much managed? The point does not lack interest, for the whole tendency of recent years is towards the creation of a larger number of unproductive officials; and the more system and organisation evident to the visitor, the more managed the concern appears, the greater credit is taken by the supreme authority in its economy. Doubtless, prior to the advent of the systematiser, the card index, and specialist activity classified by function, things were much too casual; but between such a condition and over-organisation there is a happy medium. Moderation in all things is a maxim of universal application, and there is small question but that the chief driving force of any activity is less a scientific system than a live man. System is not an organism which enjoys a sentient existence and by due multiplication evolves a line of industry, it is more a tool which requires

* This dimension and others given below refer to the diagram as originally constructed. The lineal scale of the present reproduction is about two-fifths that of the original.

* Engineering, vol. cvi, pages 53 and 54.
† Engineering, *Ibid.*, page 162, Table VI.
‡ "Graphical Methods," &c., Fig. 2.

RAPID RAILWAY CONSTRUCTION AT SLOUGH.

MESSRS. SIR ROBERT McALPINE AND SONS, CONTRACTORS, LONDON.

FIG. 1. WORKS ON MARCH 1.

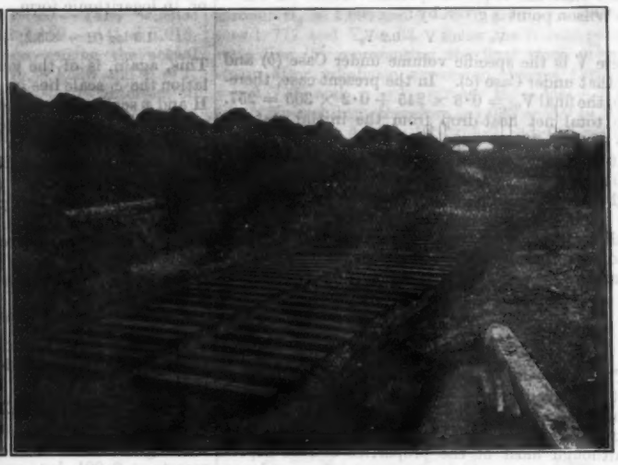


FIG. 2. SITE AFTER 16 DAYS' WORK.

alteration and re-sharpening; whose angles must be varied to the material worked, and has no sanctity of its own. Its mainspring is example, and without a live man to give impartial oversight it may immolate upon an altar of routine sacrifice the intelligence of its votaries. It is surprising how commonsense can be avoided in the intricacies of a system designed to foster good organisation.

It is quite obvious that a huge concern must be systematised for the purposes of control, to err is human and lapse must come to light, otherwise the strings which should be manipulated by a single hand would become tangled beyond rectification. Yet responsibility must be delegated and laid in varying amount upon all, system should make it easy for the organisation to function, not provide a valid excuse for difficulty. The tendency is to make rule and regulation serve for intelligence, and some of the most efficient and capable can only serve ably and well by finding out loopholes and, taking advantage of these, contrive while breaking the letter of the law to observe its spirit. The best government consists essentially in providing within certain limits the widest individual tolerance, such it is assumed is the real ideal of democracy; not in the minute direction of individual act. When individual activity threatens the comfort or convenience of the entire community then restraints must be devised.

Works management is the national problem on a smaller scale, and over-regulation is perhaps more reprehensible than a certain lack of system. After all, the individual transgressor finds punishment at the hands of the law, Parliament does not proceed to restrict the liberties of all because of individual offence. There is a type of management which adopts a contrary spirit, framing wholesale regulation for each individual malpractice; it is bitterly resented by those who conform to reasonable regulation, and nothing strains the relations between man and management more than this ill-advised and autocratic attitude. Few men object to straight dealing in a punitive way when caught out for a real breach against reasonable regulation, all resent restriction of a petty order; it argues poor statesmanship and a want of human dealing.

There is a personal element in production which no system can cure; and so long as production is by human agency, the human element will count; realisation of this forms the new industrial viewpoint. The feudal system which was destroyed mainly by the industrial revolution, was the quintessence of personal service, it had certain conveniences and responsibilities due to class distinctions and common enterprise; there is a sense in which part of its spirit is worth recapture; indeed, there is a tendency afoot to place relations on a new basis by recognition of interdependence. Personal service thrives best where restrictions are least disabling, and are generously interpreted; in other words, over-management does not tend toward pleasant relations which in themselves are no small asset. It is the difference between voluntary and pressed service, which in other quarters is realised. Management in moderation is unobtrusive, does not fuss, allows the development of individual intelligence, individual initiative; does not visit the good and the bad, the efficient and the incapable with equal severity, considers reputation and past record, gives a measure of toleration, and wins effort by abstention from undue interference. Recognition of real capacity is perhaps the key to industrial success, the measure of men is infinitely varied, while the administration of men requires a large and unprejudiced mentality and, notwithstanding that it involves great responsibility, affords peculiar pleasure to the capable.

RAPID RAILWAY CONSTRUCTION.

IN these days, when so much is heard of short hours and relaxed effort, it is interesting to be able to give some record of a rapid piece of construction which was recently carried out in connection with the Slough Motor Repair Depot. The work covered the construction of a railway station at the depot and its connecting up with the Great Western Railway. The works are situated a considerable distance from the Slough passenger station, and in the early days an enormous waste of time occurred in getting men to and from the site. In view of this, Messrs. Sir Robert McAlpine and Sons, of 50, Pall Mall, S.W., the contractors for the main works, put forward the suggestion that a railway station should be constructed at the site. On January 10, 1919, 10 days after the contract had been placed in their hands, the firm had an interview at the Superintendent's Office of the Great Western Railway. Their suggestions were agreed to, and the following day the railway officials visited the works and fixed the site of the station. Plans were very rapidly prepared, and the railway company's lay-out was received by the contractors on January 16. The contractor's suggestions with regard to these were forwarded the following day, and a meeting was called on January 24 when final plans were approved. Later on, the same day, sanctions from the War Office and Financial Department were obtained.

Work commenced on February 3, when final details were settled on site with the Great Western Railway engineer. Unfortunately very severe weather set in on February 5, with heavy snow, frost and rain, and work was rendered almost impossible up to February 22. The state of the works on March 1 is shown in Fig. 1, above. This illustration also shows the type of drag excavator used for taking out the cuttings. The remaining figures, on the present and opposite pages, illustrate perhaps better than a description the very rapid progress of the works from that date. Different views of the site after 16 days' work are given in Figs. 2 and 3. It is interesting to note that 8 out of these 16 days were wet.

The work was completed on March 14, the platforms were tested for clearances by locomotives and trains, and the station was opened for traffic on March 17. The work comprised the excavation of 17,000 cub. yards of earth, the construction of two platforms, each 800 ft. long, a footbridge, and a total length of railway of over 1¼ miles. Figs. 4, 5 and 6 are various views of the station with the footbridge and platforms, the whole of which was completed and made ready for traffic in the record time of one month. The footbridge, it may be noted, was constructed in 17 days.

The rapidity with which this piece of work was carried out is an excellent testimony to the energy and organising ability of the contractors and to the loyalty of the workmen employed. It may be of interest in connection with the matter to record that before the construction of the special station when the nearest passenger station was nearly 2 miles distant from the works, there was a daily loss of time of about 1 hour per man employed. As about 5,500 men were engaged on the works, there was consequently a loss of some 33,000 man-hours per week. The construction of the new station to a very large extent eliminated this loss.

THE NON-FERROUS MINING COMMITTEE.—The committee appointed by the Board of Trade, under the chairmanship of Mr. H. B. Betterton, M.P., to inquire into non-ferrous mining in the United Kingdom, have now completed the taking of evidence, and are preparing a report which they hope to present in a few weeks time.

RAILWAY ELECTRIFICATION IN ITALY.—H.M. Commercial Counsellor at Rome quotes *La Tribuna* as stating that the work of the Commission for the electrification of the railways, appointed by the Minister of Transports, is proceeding actively, both as regards the system to be adopted and the continuation of the works in hand in Liguria, Piedmont, and part of Lombardy. In these districts the railways general management are continuing the electrification, on the three-phase system, of the line between Turin and Genoa of about 400 km., and by means of a private undertaking the lines Turin-Milan and Milan-Voghera for another 200 km., in order to complete, as soon as possible, the principle links of this railway system. With regard to central Italy, a meeting was held recently, under the presidency of the Minister of Transports, between the various public bodies and companies interested in the utilisation of the electric power in the Umbro-Tuscan-Emilian district, in order to co-ordinate available and utilisable power for local requirements and railways. The Commission approved, from the technical point of view, plans for two thermo-electric stations, using national fuel, at Tavernelle di Perugia and Torre del Lago respectively, capable of producing about 20,000 kw. per hour. The plans have been commenced for the linking up of Rome and Naples and the Southern Provinces. A programme has also been drawn up for the extension of steam traction by oil fuel for those lines where it will take some time to provide hydro and thermo-electric power, that is to say, largely in Sicily, Calabria, Basilicata and Puglia.

RAPID RAILWAY CONSTRUCTION AT SLOUGH.

MESSRS. SIR ROBERT McALPINE AND SONS, CONTRACTORS, LONDON.

(For Description, see opposite Page.)

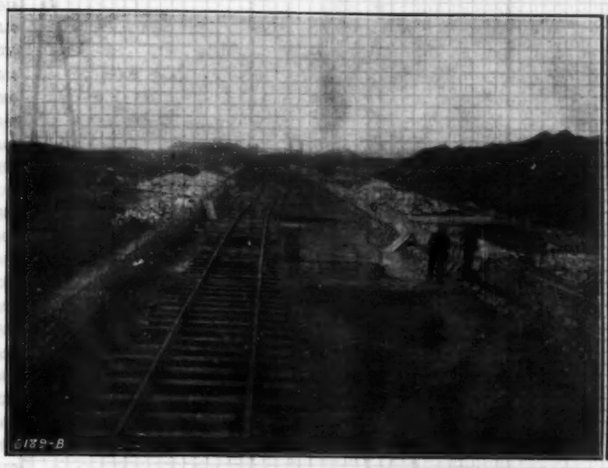


FIG. 3. SITE AFTER 16 DAYS' WORK.

FIG. 4. VIEW OF NEW APPROACH RAILWAY.

FIG. 5. VIEW SHOWING NEW FOOT-BRIDGE.

FIG. 6. VIEW OF STATION PLATFORMS.

COLD METAL-ROLLING MILLS.

THE fairs being held at the Crystal Palace, Glasgow and Birmingham reveal several directions in which engineering and other manufacturers are extending their producing facilities to supply many essentials of industries for which we were formerly dependent upon foreign countries. This is a gratifying sign of the times and ought to be encouraged in every way because, apart from the general necessity of producing more at home and importing less in order to ensure the return to normal rates of exchange, there is the need to utilise old and new factories engaged during the war on munition work. An interesting example of this trend is to be found in the exhibit at the Birmingham fair by Messrs. Vickers, Limited. The firm has taken up at their Sheffield works the making of cold rolling mills of the Continental type, suitable for rolling ferrous and non-ferrous metals, and also of special hardened nickel chrome rolls for cold rolling, and hardened special steel rolls for cold or hot rolling of rounds, squares, hexagons or other shapes.

Some months ago, the question was asked by some of the leading metal rollers in the Birmingham district why it was not possible to obtain a good English rolling mill equal to that put on the market by the Germans, as they thought British firms, who had been accustomed to extremely accurate work for guns, shells, armour, and other similar manufactures ought to be able to make a rolling mill equal to any produced. In view of this Messrs. Vickers decided to make experiments first with the rolls. When it was found that they could get a better roll, both as regards hardness, durability and uniformity, than any German roll that they had been able to obtain for the purpose of testing, it was decided that they should go in for mill making as well.

This company are now also manufacturing mills ranging from 4 in. to 24 in. diameter. At one time English firms made all the mills for the world, but they allowed themselves to be beaten by the Germans who came in with a mill designed more on the lines of a machine tool, and made of steel where cast-iron had previously been used. The Vickers' mills are fitted with hardened steel rolls having a mirror polish, steel housings, steel wheels with double helical teeth steel pinions; in fact, all the main parts of the mill are made of cast or forged steel instead of cast-iron, in order to give lightness and strength. By this means the breaking-down mill should be enabled to do more work in the same time than the old-fashioned English mill, as it will give greater pass reductions and will run quicker, and as a consequence will affect the number of annealings necessary during the operation of rolling, thus saving both in fuel and time. Although mills of this type are more costly at the outset than the old-fashioned English mill, the cost is very soon saved by the amount of extra work that is turned out, and the better finish that is ultimately given to the material.

By using a breaking-down mill of this type, the material is in a much better condition when it comes to the finishing mill, so that a far better finish and polish can be given to the surface of the sheet, or strip that is rolled by the nickel chrome steel rolls. It has not been possible up to the present to get a chilled iron roll of really uniform hardness, nor of a degree of hardness anything approaching that obtained on a hardened steel nickel chrome roll. The scleroscope hardness of the chilled iron is from 60 to 75, which represents a high average figure, whereas with the hardened steel nickel chrome roll a scleroscope reading of from 100 to 106 is quite usual, and the rolls are uniformly hard from end to end. In the chilled iron rolls blow holes are constantly found beneath the surface, which after a short time of working allow the surface of the roll to give way. With rolls manufactured on the new principle this cannot occur, owing to the homogeneity of the steel, and to the fact that the middle and necks of the roll are all of the same tensile strength, the barrel of the roll only being hardened. The finishing mills which are made in all sizes from 4 in. to 18 in. are being supplied either motor driven, or belt driven with rolls up to any length required, and the breaking-down mills run from 20 in. to 24 in., also with rolls up to any length.

The company are making these mills to standard designs, which can be modified to meet the requirements of metal rolling firms who have special ideas of their own, and in this way meet the needs of any

particular industry. As a result of this system of standardising all parts of their rolling mills, and any spares should be readily obtainable at short notice. The company have given up a large portion of their armour plate plant, both in the machine shops and treatment shops, to the manufacture of the rolls and to the machining and erection of the mills.

NOTES ON NEW BOOKS.

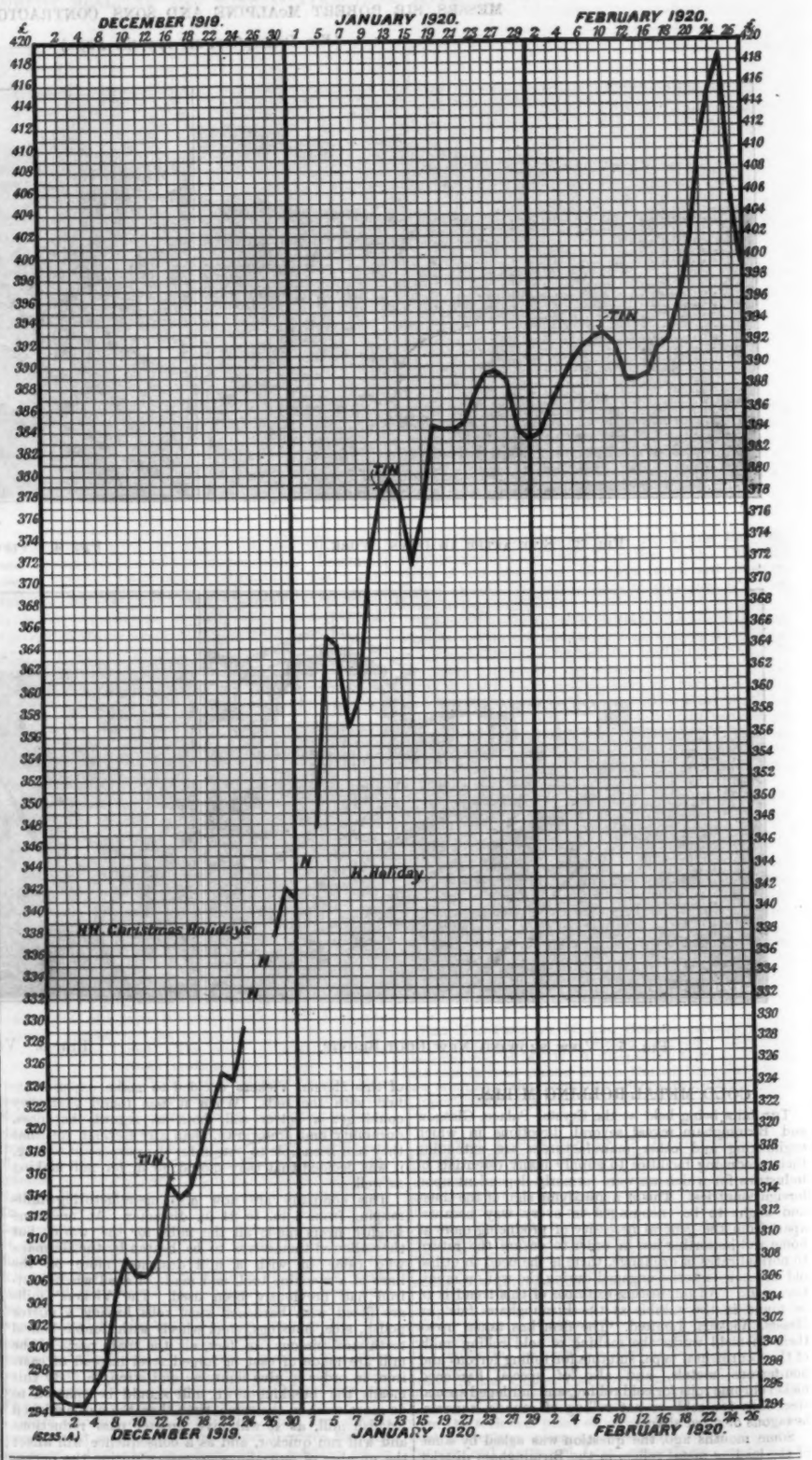
"*Asbestos*" is the title of a book by Mr. A. Leonard Summers, recently issued at the price of 2*s.* 6*d.* by Sir Isaac Pitman & Sons, Limited, 1, Amen Corner, E.C. 4. In this, the author states that "next to coal, asbestos is now undoubtedly the most important of the non-metallic mineral products of the world . . ." Leaving aside petroleum which it may be unfair to the author to quote, also Cauxite, the aluminium ore, there are to our mind many other non-metallic mineral products which are much ahead of asbestos in importance, such, for instance, as limestone and the various clays and sands, all of which render possible metallurgical operations of every description. The use of asbestos for industrial purposes is shown by the author to be quite modern history. He refers briefly to the preparation of the crude asbestos and enlarges upon the advantages offered by engine packings of which this product forms the largest constituent, and by boiler and pipe coverings made of asbestos. Special chapters deal with other miscellaneous uses of asbestos, with synthetic fireproof materials such as "ralite," "litholite," &c. The book would appear to come none too soon, since in the words of the author, ". . . a great portion of the public has never heard of asbestos, and I have actually been asked if it is a species of fish!" For this reason, our readers, like we, will hope that it may have a wide circulation.

When an annual work of reference has reached its thirty-third year of issue there can be little doubt that it is generally appreciated by the class for whom it is intended, though it may be questioned whether the later editions differ materially one from another. A certain amount of the technical data found in such publications is necessarily of a permanent character, so that it appears without alteration from year to year, but much of it requires careful revision to keep it up to date. Although this work is not always carried out as thoroughly as it might be, there is ample evidence that it has not been neglected in the case of the "*Mechanical World Year Book*," a copy of which has recently come to hand for the current year. Two entirely new sections, one dealing with water and hydraulic work and the other relating to the heating and evaporation of liquids, have been added to the 1920 edition of this work. The former section includes some useful diagrams which give the friction of water in pipes at a glance, and also contains extensive notes and data on pumps and pump fittings, the applications of hydraulic power, hydraulic accumulators and presses, and other cognate matters; while the other section contains information on feed heaters, evaporators, &c. Additions have also been made to the section devoted to compressed air and also to the tables of screw threads, while the matter generally has been revised and brought up to date wherever such revision was necessary. Other sections of the book deal with steam engines and boilers, internal-combustion engines, materials, structures, power transmission, machine work, &c., notes, tables and data being included on these and other subjects of interest to engineers. The price of the book is 2*s.* net, and it is published by Messrs. Emmott and Co., Limited, who have offices at 65, King-street, Manchester, and 20, Bedford-street, London, W.C. 2. It is bound in red cloth covers and contains a diary for the year in addition to the notes and data.

Of the many year-books and annuals which now appear in such abundance the "*British Journal Photographic Almanac*" is probably amongst the most sought after because of the ever-widening field of application of photographic processes; this is so even in engineering establishments which have work ranging from the millions of blue-prints to the pictures from the laboratory of the photo-microscopist. The principal article in the issue of the Almanac for 1920 deals in a very helpful way with beginners' failures in photography, both with plates and printing processes; the various standard and proved formulæ which are given are quite up to date and the numerous tables referring to chemicals, exposures and optics make the book a well of information to all who are engaged in photographic pursuits. It is published by Messrs. Henry Greenwood & Co., Limited, 24, Wellington-street, Strand, London, price 1*s.* 6*d.* in paper cover and 2*s.* 6*d.*, cloth bound.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



THE LATE MR. CHARLES H. HANDS.—We regret to read in *The Birmingham Post* of the death, on February 27, of Mr. Charles H. Hands, of Edgbaston, Birmingham, a director of Messrs. John Hands and Sons, Belmont-row, one of the oldest engineering firms in Birmingham. Mr. Hands was a member of the Management Board of the Engineering and National Employers' Federation. As chairman of the ironfounders' section of the federation he conducted the whole of the negotiations locally on behalf of the employers during the recent moulders' strike, and attended the various conferences up to the settlement of the dispute.

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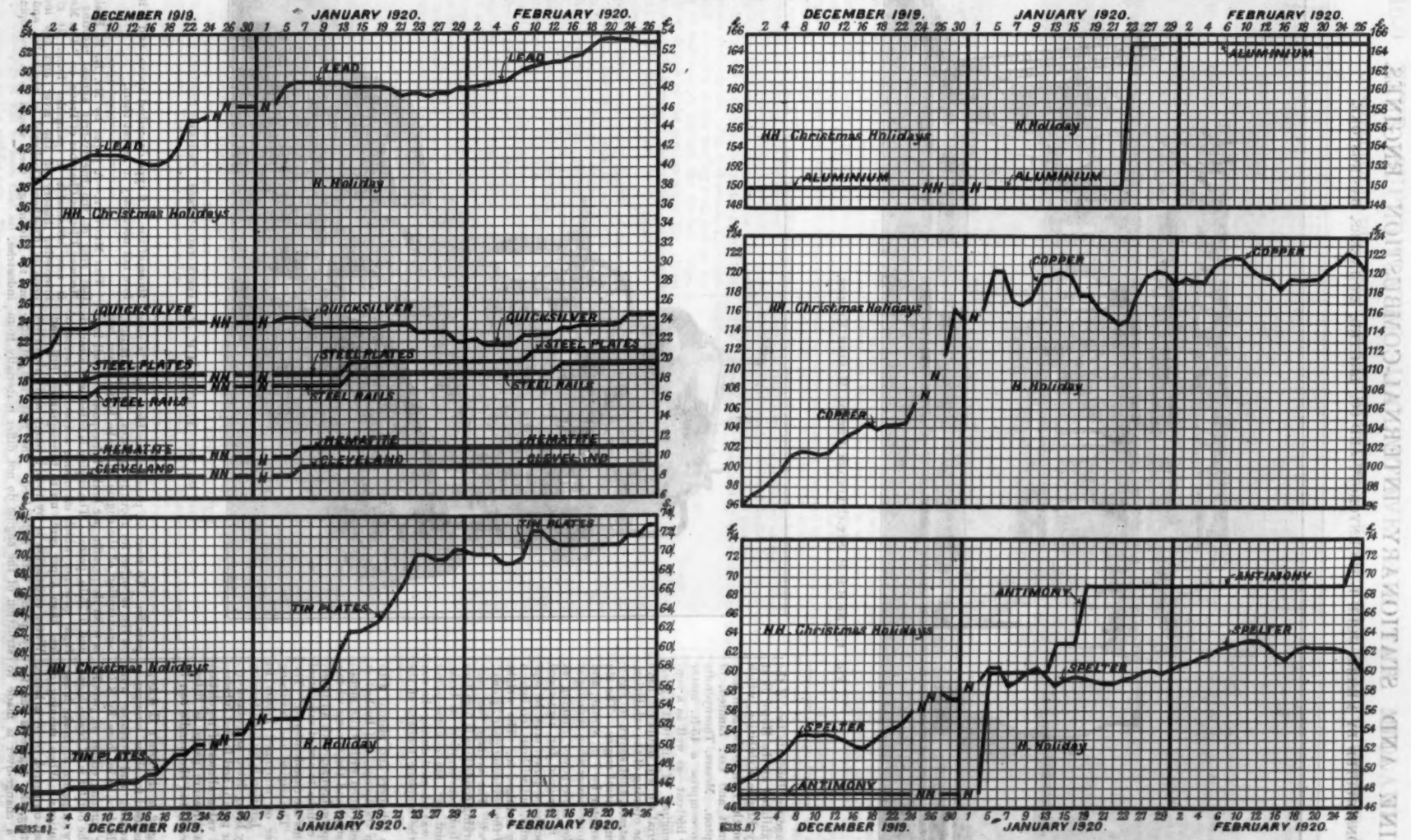


NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. coke free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

PORTABLE AIR COMPRESSOR PLANT.—The Consolidated Pneumatic Tool Company, Limited, Egyptian House, Piccadilly, London W. 1, have added to their specialities a convenient inexpensive type of portable air compressor plant, which can be readily and conveniently used for a number of purposes, such as boiler scaling, metal chipping and caulking, light riveting, &c. The plant consists of a small water-cooled single cylinder vertical air compressor, 4½ in. bore by 4½ in. stroke, having a capacity of 21 cub. ft. of free air per minute at 100 lb. pressure. This is driven by belt from a 5-h.p. electric motor; which is easily coupled up to any main having a suitable voltage by means of a trailing cable. The whole is mounted on a bogie strongly constructed of angle iron; the air receiver is underslung, thus securing economy in space. For boiler scaling the plant is an ideal one, sufficient for operating one or two hammers according to size. In these days of high standing charges, when it is of the greatest importance that plant should be kept running at highest efficiency, the saving in time and labour to be derived from using pneumatic scaling is a serious consideration. One pneumatic hammer will easily do the work of four ordinary hand-scaling hammers besides ensuring perfect scaling without injury to the plates. The company supply portable plants of all sizes arranged for steam, electric, petrol and oil drives, which give every satisfaction under varying conditions of service.

MARINE AND STATIONARY INTERNAL-COMBUSTION ENGINES.

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, ENGINEERS, BASINGSTOKE.

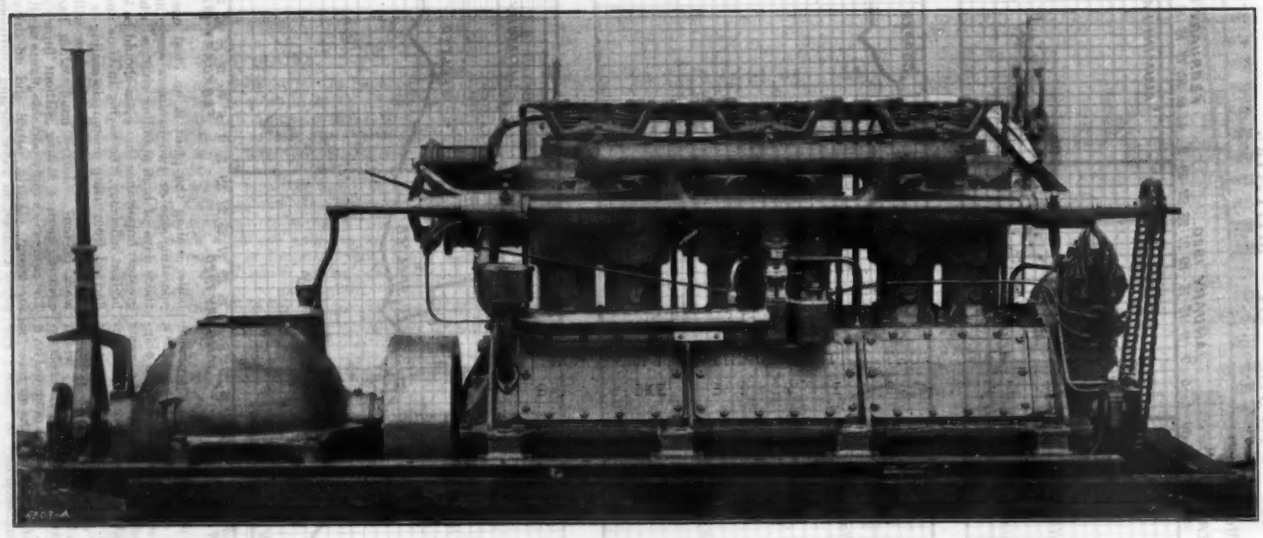


FIG. 1. 70 B.H.P. SIX-CYLINDER PETROL MARINE ENGINE.

IN the figures on this page we illustrate two of the engines which are to be exhibited at the Motor Boat and Marine and Stationary Engine Exhibition, which will be held at Olympia from the 12th to the 20th inst. Messrs. John I. Thornycroft and Co., Limited, of Basingstoke and Southampton. Messrs. Thornycrofts exhibit at the show is to comprise a 45-ft. motor cruiser and a 28-ft. motor lifeboat—as well as a considerable assemblage of engines of different types. Some of this further material we will doubtless have occasion to refer to after the opening of the exhibition. Of the two engines we illustrate, that shown in Fig. 1 is the firm's Z 6 type marine petrol engine. The six cylinders are each 4 in. diameter by 7 in. stroke, and the engine gives 56 brake horse-power when running at 1,000 r.p.m., and 70 brake horse-power running at 1,375 r.p.m. The engine is designed for high-speed boats in which the weight per horse-power must be kept down to reasonably low limits, but without too light a type of construction being indulged in. The weight of the engine is 9¼ cwt., of the reversing gear 3¾ cwt., and of the stern gear 1 cwt. The average fuel consumption under normal working conditions is 5 gallons per hour, and the guaranteed consumption on brake horse-power test is 0·9 pint per brake horse-power at full power. The engine was adopted during the war as the standard type for the seaplane tenders of the R.A.F.

The engine has cast-iron cylinders and pistons with connecting rods made from stampings, and bushed at the lower ends with gun-metal lined with white metal. The crankshaft is of mild steel and the timing wheels are of mild steel and phosphor bronze, with an intermediate fibre wheel. The camshafts are of mild steel ground all over, and the cams are case-hardened. The valves are of nickel steel. The engine and reversing gear are mounted together on machined Z-bars to secure accurate alignment. Ignition is by high-tension magneto, a coil and battery being fitted as a stand-by. Water circulation is by gear pump, and forced lubrication is arranged. A relief valve allows of regulation of the oil pressure and a pressure gauge is fitted. The starting gear is overhead, and the handle can be fitted at either end.

The engine shown in Fig. 2 is the firm's C. 4 type of stationary engine, and is used for ships' emergency lighting sets, pumping, welding and portable work generally. It has four cylinders, 6 in. bore by 8 in. stroke, and is suitable for running either as paraffin or petrol. With paraffin the output is 47 brake horse-power at 750 r.p.m., and with petrol 53 brake horse-power at the same revolutions. When running on paraffin the engine is started on petrol, or by a lamp. If petrol is used for starting, the engine is run for about 10 minutes before a change-over is made to paraffin. To start on paraffin the blow lamp is used on the vaporiser for about 10 minutes The guaranteed consumption of the engine on brake horse-power test is 0·85 lb. paraffin per brake horse-power at full load and 0·75 lb. petrol. The engine is fitted with a centrifugal governor which maintains a speed variation of less than 5 per cent. up to three-quarters full load. Water circulation is by rotary pump and lubrication by pump with sight feed. The materials of construction of the engine do not differ materially from those of the Z. 6 type described above, and it is therefore not necessary to repeat them.

FIG. 2. 47–53 B.H.P. PARAFFIN OR PETROL ENGINE.

THE MEDWAY.—A paper by Mr. R. F. Brain, read last year at the twenty-first annual meeting of the Medway District Chamber of Trade, on "The Medway," is now obtainable in pamphlet form. It gives an interesting history of the river and the industries upon it, Chatham Dockyard in particular, and points out the advantages there would be in developing these industries.

0-10-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE MIDLAND RAILWAY.

CONSTRUCTED TO THE DESIGNS OF SIR HENRY FOWLER, K.B.E., CHIEF MECHANICAL ENGINEER, DERBY.

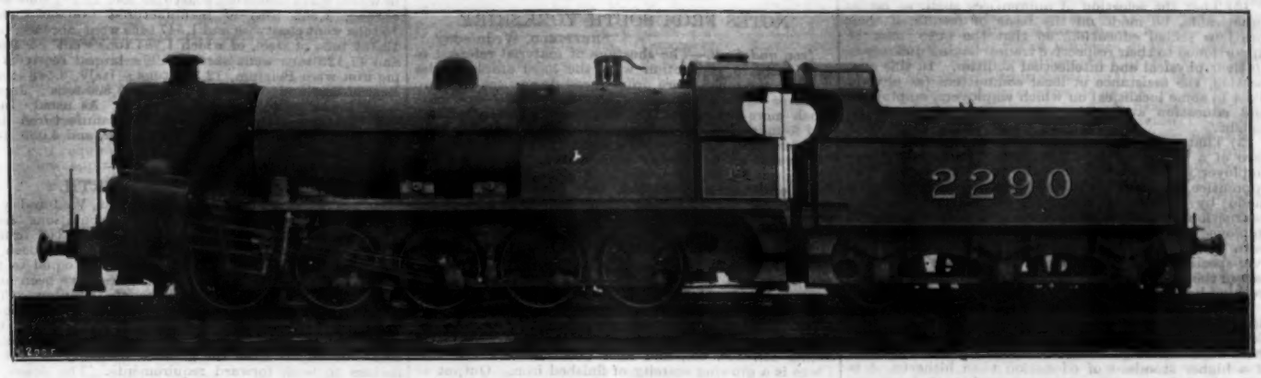


FIG. 11.

A NEW 0-10-0 type locomotive, designed by Sir Henry Fowler, K.B.E., and recently built at the Midland Railway Company's works, Derby, is illustrated in Plates XVII and XVIII and on the present page and page 314. This engine possesses many unusual features. It has been designed for work on the Lickey incline, Bromsgrove, on which the gradient is 1 in 37·7. Originally it was proposed to build a 0–10–0 type of tank engine, but this was abandoned in favour of a tender engine which allowed greater boiler capacity without excessive wheel loads. The designs for the engine illustrated were prepared prior to the war, but the construction was deferred till recently.

Figs. 1 and 2 on Plate XVII, give respectively a sectional elevation and plan of this locomotive. Figs. 3 and 4, Plate XVIII, give the leading dimensions, weights &c. Fig. 5, on the same plate, gives on the left-hand a section through the cylinders, and on the right a half-end elevation at the front. Fig. 6 shows on the right-hand a half elevation at the trailing end, and on the left hand at half section through the fire-box. Figs. 7 to 10 give details of the motion while Fig. 11, on the present page, is a general view of the engine, and in Figs. 12 to 15, page 314, are shown views of the cylinder castings.

The boiler is fitted with a superheater of the usual Midland pattern, having 27 sets of elements. The fire-box is 10 ft. long, and has a grate area of 31½ sq. ft. The boiler barrel is 5 ft. 3 in. diameter, and 14 ft. long. It will be observed from the drawings that the fire-box is tapered in two directions, the crown sloping downwards toward the back, and the sides inwards in the same direction, the back plate being, in fact, similar to those used on the company's compound express engines. Four 3½-in. safety valves are fitted, set to blow off at 180 lbs., though the boiler is designed for a working pressure of 200 lbs. The boiler is fed by two hot water injectors, and special provision is made for warming the water in the tender by utilising steam which would otherwise be blown off at the safety valves.

There are four cylinders, 16½-in. diameter by 28-in. stroke. These are cast in pairs (see Figs. 12 to 15) one steam chest to each pair, and bolted together. The interesting feature of the cylinders is that cross ports have been introduced, which make it possible for one piston valve to supply both cylinders on one side of the engine. This is clearly shown by the photographs Figs. 12 and 13, from which it will be seen that the front piston valve head serves the front port of the outside cylinder, and the back port of the inside cylinder, and *vice versa*. The covers at the back and front of the cylinders are the same diameter, which enables the cylinders for both sides of the engine to be cast off one pattern. The piston valves are 10 in. diameter, and are driven by Walschaert's motion, the cut-off in full gear being 75 per cent. The following are particulars of the valve gear:—

Throw of lazy crank	7½ in.
Angle of lazy crank	88 deg.
Outside lap of valve	¾ in.
Inside clearance of valve... ...	⅛ in.
Clearance of die—	
Top	⅛ in. + 1/16 in.
Bottom	⅛ in. + 3/32 in.
Slip of die—	
Top	⅛ in.
Bottom	⅛ in.

From the drawings it will be seen that all the connecting rods drive on to the middle axle. The incline is 1 in 7 to the horizontal, and the intermediate leading axle is cranked to clear the inside connecting rods.

Mechanical lubrication is provided, both for the cylinders and axle-boxes, Midland lubricators being used. The engine is fitted with steam reverse gear, the steam and water cylinders being fixed to the frames close to the reversing shaft, and operated through pipes and valves on the footplate. Owing to the severe gradient on the Lickey incline, it is imperative that ample brake power should be available, and from the drawings it will be noted that all the wheels are braked, the front three pairs being operated by a steam cylinder and shaft placed just behind the driving axle, and the two hind pairs of wheels by a cylinder and shaft placed under the drag-box. In addition, owing to the comparatively light tender, a hand brake has been fitted on the engine, and this acts on all wheels.

The following are the leading dimensions of this engine and tender:—

LOCOMOTIVE.

Cylinders, number	Four.
Cylinders, diameter	16½ in.
Cylinders, stroke	28 in.
Piston valves	Outside admission.
Piston valves, diameter ...	10 in.
Valve motion...	Walschaert.
Wheels, diameter	4 ft. 7½ in.
Boiler band, diameter ...	5 ft. 3 in.
Boiler band, length	14 ft.
Fire-box width, outside ...	4 ft. ⅛ in.
Fire-box length, outside ...	10 ft.
Tubes, length...	14 ft. 4¼ in.
Tubes, diameter	1¾ in. and 5⅛ in.
Tubes, 1¾ in. number ...	147
Tubes, 5⅛ in. number ...	27
Heating surface, fire-box ...	158·25 sq. ft.
Heating surface, tubes ...	1560·0 sq. ft.
Heating surface, total ...	1718·25 sq. ft.
Superheater surface	445 sq. ft.
Grate area	31·5 sq. ft.
Designed boiler pressure ...	200 lb. per sq. in.
Working boiler pressure ...	180 lb. per sq. in.
Tractive force at 85 per cent. boiler pressure	43,312 lb.
Weight of engine in working order	73 tons 13 cwt. 1 qr.

TENDER.

Tank capacity	2,050 gallons.
Coal capacity...	4 tons.
Wheels, diameter	4 ft. 1 in.
Weight in working order ...	31 tons 11 cwt. 2 qr.

LOCOMOTIVE AND TENDER.

Total weight in working order 105 tons 4 cwt. 3 qr.

THE TRAINING OF SHIPYARD APPRENTICES.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with considerable interest the Report of the Committee of the Institution of Naval Architects on the Education and Training of Apprentices in Shipyards and Engine Works, and your summary of it in your current issue. It is a subject of first-class importance, and I hope you will encourage discussion in your columns, especially on that phase of the question which concerns the means of overcoming the difficulties which will arise in meeting the provisions of the new Education Acts without seriously interfering with the conduct of shipyards and engineering works. As to this part of the problem, the report of Sir John Biles's Committee gives no guidance. The general question of the education and training of apprentices is of importance not only to employers and workers in the industries concerned, but also to all concerned with the future industrial welfare of this country, on account of the great importance of these industries.

There is no doubt that the technical and trade education of apprentices in the shipbuilding and engineering trades is at present in a most unsatisfactory condition, and indeed it is no exaggeration to state that it is hopelessly inadequate to meet the needs of the present time. It has long been recognised by those who have given thought to the subject that the present system of apprenticeship to any given trade in most of our large industrial establishments is not producing the type of efficient young journeyman required. With the increase in size of modern industrial establishments and the consequent large number of apprentices employed, the problem of superintending the training of the apprentices has grown beyond the capacity of foremen already burdened with responsibilities for the working of their department. Too often is it the case that from the day a lad starts to serve his apprenticeship till the end of his five years it is nobody's business to see that he is properly instructed in the work of his trade, and that such skill and knowledge as he may acquire during the five years of his apprenticeship are entirely due to his own observation and effort. Information gained in this way is undoubtedly of the very highest value, but unfortunately there is no guarantee that the information so acquired is sound theory or good practice, and in any case there is no justification whatever for allowing apprentices to spend years picking up scraps of information—often of doubtful value—relative to their trade when correct information could be easily imparted to them in a very short time by a competent instructor.

The necessity for a higher degree of technical training and a broader general education is now very generally accepted by employers, and in a number of cases earnest effort has been made to provide this within the works. The provisions of the new Education Acts carry the matter a stage farther, for under these Acts the age and scope of education are considerably extended and are made compulsory up to the age of 18. That such an extension of the available education facilities will ultimately prove of immense benefit to the country cannot be doubted, but the grafting of a scheme of such complexity upon the existing industrial organisation naturally calls for a large measure of earnest thought and probably a considerable rearrangement of existing practice, in order that the minimum disturbance of industry may be caused.

The case of shipyards is considerably more difficult than engine works, due to the fact that a large number of trades are involved, also to the fact that in the case of riveters the rivet heater is an essential part of the squad, and can rarely be dispensed with without throwing the whole squad out of work. In this case it seems probable that the provisions of the new Act will eliminate rivet heaters under the age of 18 years, except in the case of squads of apprentice riveters, where the riveters are themselves under 18 years of age. Difficulties such as the above are bound to arise in many trades, and in the case of many small firms who are largely dependent on apprentices for turning out their work. Thus a broad-minded spirit of co-operation between employers and the Local Education Authorities entrusted with the administration of the new Acts will be essential to the success of the scheme.

The recommendations of the Committee of the Institution of Naval Architects form a striking illustration of the broad-minded and progressive spirit in which the principal employers of labour in these industries have considered the question, and notwithstanding your summary of these, I think it is essential to a full and candid criticism that they should be given in full. They are as follow:—

(1) That it is desirable to have an indentured system of apprenticeship, where practicable, or at the least a definite understanding between all the parties concerned, involving direct obligations on both sides, viz., on the part of the apprentice to learn his trade (in the broadest sense of the term), with diligence and application, and on the part of the employer to teach the apprentice his

trade and assist him in every practical way to continue and improve his education during apprenticeship. It should be borne in mind that facilities must be given for apprentices to attend day classes during apprenticeship in accordance with the provisions of the new Education Acts.

(2) That the selection of apprentices shall, as far as practicable, be made on the basis of results of their previous school education, so that the boys may be apportioned to their respective trades, having due regard to their physical and intellectual abilities. In this connection, the assistance of local committees (as already exist in some localities) on which employers, employees, and education authorities are represented should be sought.

(3) That apprentices should be under the specific care of a supervisor of apprentices, appointed by the employer to oversee the training and education of the apprentice. If necessary, this appointment might be made by groups of firms or employers. Practical instruction should be given to apprentices by selected employees, facilities being given to the apprentices to learn their respective trades, care being taken to avoid over-specialisation. Employers should take an active part in the direction of the apprentices' education outside working hours.

(4) That as the proportion of boys, other than apprentices (now mostly under 16), will, owing to the new Education Act, be greatly reduced in the future, and as these boys will be generally of a more advanced age and of a higher standard of education than hitherto, it is desirable to give them an opportunity of becoming apprentices or of taking some satisfactory and permanent place in the industry.

(5) That facilities should be provided whereby only one boy who desires to do so can change his trade, subject to his progress in school and works being satisfactory.

(6) That facilities and assistance should be given to the best qualified apprentices, judged by their school and works records, to take a recognised university course in naval architecture and engineering, the time so spent counting as part of their apprenticeship.

(7) That facilities should be given to boys who remain at school after the age of 16 to enter the works as apprentices. These facilities should admit of their readily taking part in the scheme for following a university course as indicated in Clause 6.

(8) That wherever possible the development of the social or civic side should be encouraged by the formation of apprentices' clubs, as already established by some firms.

That there should be a definite agreement between apprentices and employers as to the duties of each party during the apprenticeship period, and that such agreement should be loyally carried out by both parties is obviously the first essential to the success of any scheme for the improvement of the education and practical training of apprentices. As has already been said, the majority of works at the present time make little or no attempt at systematic training or instruction during working hours, and it is unfortunately equally true that a very large proportion of apprentices make no effort to avail themselves of the benefits of the evening classes which are at present carried on for their benefit. The provisions of the new Education Acts make provision for day time instruction of lads during their apprenticeship, and the manner of carrying out this provision will require the most serious consideration. The question whether the instruction should be given in each works, or whether several works should combine to establish a school of instruction clear of the works and run in association with the local Education Authority will probably be decided by district requirements, but there does not seem to be any doubt but that practical trade instruction should in all cases be carried out in each work under a competent instructor.

With regard to the selection of boys for apprenticeship it has been found to be a good plan to hand all applications to the welfare supervisor for investigation as to the fitness of the applicant and his physical suitability for the job selected. In this way many errors of judgment in the selection of a trade are discovered and corrected before valuable time is lost to the boys. The appointment of a supervisor of apprentices, unless his function be limited to instruction clear of the shops, is apt to lead to somewhat serious friction between the supervisor and the head foremen of departments. Where the apprentice comes under the authority of a works foreman, as he is bound to do in working his way through the shops, any interference on the part of the supervisor is naturally resented and the resultant friction does much to impair the efficiency of the training scheme as a whole.

In the matter of social welfare work the supervisor can be of very great assistance, and where he is competent to do so he might conduct lectures on technical subjects to the apprentices clear of the workshops, but it will probably be found that the best results will be got when the functions of the supervisor and those responsible for shop organisation and production are clearly defined, so as to avoid the possibility of divided authority in the case of any apprentice.

Facilities for a boy changing his trade are as a rule readily granted by employers, but investigation by the welfare supervisor previous to a boy starting his trade would in all probability very considerably reduce the likelihood of an initial mistake in selection of a trade.

The remaining recommendations of the committee deal broadly with the necessity for the provision of facilities for higher education of youths of outstanding ability, and are entirely to be commended. In general, the findings of the committee give a plain indication that employers are willing to play their part in assisting in the improvement of the educational facilities of the worker, and it would be of interest and benefit to have some assurance that the trades unions are equally willing to lend their aid in furtherance of this most vital object.

Yours truly,

"SHIPYARD MANAGER."

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The shortage of material referred to previously in connection with the local staple trades has become much more pronounced during the last two or three weeks. Although the furnaces are producing much more basic than formerly, and supplies of forge and foundry have in consequence diminished, deliveries of basic fall short of requirements, and considerable inconvenience is thereby experienced, particularly at rolling mills. In the case of several of the very largest engineering firms, work has been impeded to such a degree that manufacturers have been obliged to resort to the use of Siemens steel where basic has hitherto been employed. The result is that costs are being forced up at a rate little short of alarming. Basic iron has reached the high level of 11*l.* 10*s.* per ton. Forge and foundry are advancing in proportion. Derbyshire makers are quoting 10*l.* 2*s.* 6*d.* for forge and 10*l.* 7*s.* 6*d.* for foundry. Furnaces situated in more distant parts are asking still higher figures. The demand for hematites is much in excess of the available tonnage. West Coast makers are asking 12*l.* 17*s.* 6*d.*, and East Coast makers 11*l.* 15*s.* There is a growing scarcity of finished iron. Output at the bar mills is booked up on contract accounts for nine months ahead As much as 33*l.* is being paid for early deliveries of bars. A feature of the overseas demand is the revival in crucible steel. Italy, France and Belgium have greatly increased their requirements. Sheffield trade with America in high-speed steels is still in the ascendant. Tool-makers have plenty of orders, but are held up for lack of material.

South Yorkshire Coal Trade.—The position has somewhat improved, following the maintenance of increased outputs at the pits, though house-coal merchants are still sadly in arrear with orders. Deliveries to iron and steel works are barely sufficient to meet current needs. In quite a large number of cases works are having to draw on emergency stocks. Public utility concerns report improved deliveries, though their stocks have not yet reached the safety margin. Cokes of all descriptions are in strong demand. Maximum prices are the general rule. Quotations:—Best branch hand-picked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty slacks, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Values of Cleveland pig-iron are unaltered, but as makers have practically none to sell quotations are of little moment. Shortage of supply is reported more acute than ever. Buyers would really welcome higher prices if such action would release iron, but little hope can be entertained of any material improvement of supply in the near future. Home and foreign demand is as insistent as ever, and customers in certain quarters abroad are prepared to pay phenomenally high rates. For home consumption, No. 1 is 182*s.* 6*d.* and No. 3, as well as the lower qualities, is 175*s.*; and for shipment to France, Belgium and Italy, the former is 187*s.* 6*d.* and the latter are 180*s.* Any Cleveland iron available for sale to other destinations abroad readily realises at least 230*s.*

Hematite Iron.—Dearth of East Coast hematite is very pronounced, and as recognised market quotations are declared to be altogether unremunerative, producers are very disinclined to sell. Nominally, No. 1 is 222*s.* 6*d.* and mixed Nos. are 220*s.*; and the quotations are 232*s.* 6*d.* and 230*s.*, respectively, for export to France, Belgium and Italy.

Foreign Ore.—Values of foreign ore are still ascending. Sellers are in a very strong position and confidently anticipate substantial business at high rates. Freights are stiffer, and tonnage is difficult to arrange. With the market quotation for best rubio 50*s.* to 51*s.* on the 17*s.* parity freight, Bilbao-Middlesbrough, the ex-ship Tees price of rubio may be put at 72*s.* to 73*s.*, as the freight from Bilbao is 39*s.*

Coke.—Coke very scarce and stiff. Average blast-furnace quality 50*s.* 6*d.* at the ovens, and low phosphorus sort 53*s.* at the ovens.

Manufactured Iron and Steel.—Very little new is ascertainable just now concerning finished iron and steel. The various branches are chock full of work, and there is very great congestion at many yards, due chiefly to the serious shortage of wagons. Business is almost at a standstill, manufacturers being so busily engaged endeavouring to fulfil obligations they are already committed to, that they cannot entertain even a portion of the very large volume of trade offering. The following minimum quotations are for home trade:—Common iron bars, 24*l.*; marked bars, 26*l.* 10*s.*; steel ship, bridge and tank plates, 21*l.*; steel boiler plates, 26*l.* 10*s.*; steel angles, 20*l.* 10*s.*; packing steel (parallel), 17*l.* 5*s.*; packing steel (tapered), 21*l.* 10*s.*; steel joists, 20*l.* 10*s.*; soft steel billets, 20*l.* 10*s.*; heavy sections of steel rails, 19*l.* 15*s.*; fish plates and sleepers, 24*l.* 5*s.*; and galvanised, corrugated sheets, 50*l.* to 53*l.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during the month of February were on a better scale than was at one time looked for, totalling 56,637 tons, of which 11,374 tons went coastwise and 45,263 tons went abroad. Last month's clearances comprised 41,966 tons of pig-iron of which 9,375 tons went coastwise and 32,591 tons went abroad, 1,562 tons of manufactured iron, of which 15 tons went coastwise and 1,547 tons went abroad; and 13,109 tons of steel, of which 1,984 tons went coastwise and 11,125 tons went abroad. The largest receivers of pig-iron were Belgium, 12,358 tons; Italy, 6,548 tons; East of Scotland, 5,560 tons; Spain, 3,800 tons; Japan, 2,410 tons; and France, 2,149 tons. As usual, India was the largest customer for both manufactured iron and steel, taking 382 tons of the former, and 5,059 tons of the latter.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Very active conditions have prevailed in the Scotch steel trade during the month of February, and the demand from buyers has been on a large scale. The output has been barely equal to the requirements of consumers who at times have been hard pressed to keep their establishments running. Conditions such as prevail at the present time have never existed before, and it is interesting to note that not only is the total output for the next few months already sold, but buyers have the greatest difficulty in getting makers to book forward requirements. The desire on the part of the latter is to get a lot of the present orders cleared off before entering into fresh engagements. The pressure for ship plates is indeed very heavy, and several shipbuilding yards have had occasionally to slow down owing to shortage of plates, &c., but some of American manufacture, purchased by the Government during the war, having recently been secured by builders have helped considerably at a time of great scarcity. Boiler plates are also in big demand, and sectional material which was being freely offered not very long ago is now the subject of much activity. Makers of black steel sheets continue very busy and heavy order books are general. Prices have advanced sharply, the Black Steel Sheet Association having announced last week that all orders on hand will be advanced by 70*s.* per ton, and that new business will be the subject of negotiation when buyers submit specifications. The basis price is now 33*l.* per ton, net, f.o.t. works, and it is just early enough yet to see if this high quotation will have any effect on buying. The export side of the steel trade is extremely quiet, but inquiries for all kinds of material are very numerous, and buyers are even willing to pay respectable premiums to secure deliveries. Producers are so busy with home business that they are unable to entertain overtures for shipment lots, with the result that very little is going through on export account.

Malleable Iron Trade.—No change falls to be reported in the malleable iron trade of the West of Scotland, and much activity prevails at the various works. Most of this is on home account, and owing to the very pressing demand of the home trade many rather tempting export orders are not receiving much consideration. The position at the moment is that makers can actually pick and choose for themselves. Pig-iron scrap having reached a very high level of price it was fully anticipated that bar iron producers would have further raised their prices before now, but it has been agreed to make no alteration meantime.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade there has been no falling-off in demand, and with all grades of iron very scarce there is no difficulty being experienced in disposing of outputs. Foundry iron is particularly active, and in order to secure supplies consumers are willing to pay a high figure, but producers continue the rationing system in order to keep everybody going. Prices have now reached a new record, and No. 1 foundry iron is quoted at 12*l.* 5*s.* per ton and No. 3 at 12*l.* per ton, net, f.o.t. blast furnaces, for home consumption; while for export the prices are, No. 1 13*l.* 5*s.* per ton and No. 3 13*l.* per ton, net, f.a.s. Glasgow. Owing to the shortage of vessels on the inward ore traffic producers are often very short of supplies, and as very high freights are now demanded current quotations are naturally very stiff. Hematite iron is not over plentiful and the local steel works are consuming large quantities. Prices have been very firm of late, and last week the Scotch ironmasters advanced the price by 17*s.* 6*d.* per ton for March delivery. The present quotation is now 12*l.* 10*s.* per ton, delivered at the local steel works.

Scotch Shipbuilding.—The Scotch shipbuilding returns for the past month are both interesting and encouraging, and prove the fact that a great amount of work had been booked after the armistice. The yards are all busy, and about the only drawback is the shortage of supplies of steel and other materials. Given a plentiful supply of these, and freedom from industrial troubles, there is little doubt but that a new tonnage record could easily be put up for this year. Turning to the output for February we have the following figures:—

Vessels.		Tons.
The Clyde	15	32,729
The Forth	1	4,650
The Dee, &c.	4	1,086
Total	20	38,465

These figures compare favourably with the same month in previous years, and are a fair average. The Clyde total is rather under that for January, but when the two months are added together we have a total of 25 vessels of 72,639 tons, which, in recent years, has only been bettered on two occasions—in 1912, with

83,135 tons, and 1907, with 79,409 tons. The launches during the first two months of last year made 42,639 tons, while for the record year of 1913 the total was only 56,805 tons, so that the figures for the present year are well over the average. Turbine steamers were not a feature of the output last month, which makes a difference from January, but general cargo-carrying steamers of good average size formed the bulk of the month's work. New contracts have not been very numerous, but several interesting orders have been booked.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Markets.—Export business remains virtually at a standstill because of the continued pressure for inland requirements and the refusal of the authorities to release supplies for shipment abroad. A priority list of releases has been arranged and first preference is given to inland requirements, then to coastwise bunkers, then to bunkers for steamers proceeding abroad in ballast, and then to shipments to British coaling depots abroad. After these requirements have been met there is practically nothing available for export, and thus the restrictions of the authorities are tantamount to an embargo on foreign business. The docks are crowded with shipping and, in addition, a large number of steamers are in the Barry and Mumbles roads awaiting cargo notwithstanding that many British vessels have been ordered abroad in ballast to load homeward cargoes. Again there is a large number of foreign vessels on time charter held up waiting cargoes. The coal trade is, as a matter of fact, in a chaotic condition and operations are practically suspended, as almost the whole of colliery outputs are earmarked by the authorities and there is practically nothing available for sale. Indeed, collieries are behind with contract commitments and are refusing to negotiate further business. Exports of coal, foreign, last week totalled 354,033 tons, of which 219,559 tons were despatched from Cardiff, 61,626 tons from Newport, 30,226 tons from Swansea and 42,622 tons from Port Talbot. Of the total shipment more than 60 per cent. were sent to France.

New Miners Wage Proposals.—At a special conference of the South Wales Miners' Federation, held at Cardiff this week, a new movement was inaugurated with a view to secure a revision and unification of the rates of wages payable to the different grades of colliery workmen. At present there are between 30 and 40 grades of workmen in the coalfield with a correspondingly varied rate of wages. The Executive Council of the federation suggested that all the workmen should be classified into three grades only, but the conference went a step further and practically decided that there should be only two grades. The actual rates to be fixed for the two classes were not decided upon, so that the lodges may have an opportunity of considering the matter in order that the final decision may be arrived at when the conference re-assembles next week. The programme thus outlined will mean a very considerable increase in the wages of the lower paid men and, therefore, will, if put into operation, add very greatly to the present cost of production.

The Iron and Steel Trades.—An unauthorised strike of steel workers in the Swansea district, which has rendered about 18,000 men idle since Monday last, has brought business to an almost complete standstill. The tin-plate trade is also suffering from the effects of the stoppage, and idleness is certain to increase according to the duration of the strike, for the tin-plate works cannot keep going without a regular supply of steel bars. Meanwhile the demand for plates is not so pressing as it was a short time ago, but as most makers are already booked up with contracts prices are not appreciably altered, and are on the basis of 72*s.* to 74*s.* 6*d.* for standard boxes. Tin and sheet bars are firm at 30*l.* per ton, with operators disinclined to do business while conditions are so unsettled.

"JAMES FORREST" LECTURE.—The twenty-sixth "James Forrest" Lecture will be delivered at the Institution of Civil Engineers on Tuesday, April 20, at 5.30 p.m., by Sir Dugald Clerk, K.B.E., F.R.S., M.Inst.C.E., the subject being "Fuel Conservation in the United Kingdom."

FARM TRACTOR TRIALS, 1920.—Entries for the 1920 tractor trials promoted by the Royal Agricultural Society, with whom the Society of Motor Manufacturers and Traders are collaborating, will now be accepted up to March 27. Slight alteration has been made to the regulations and there are now seven classes instead of six as formerly. The revised list of classes stands as follows: Class 1: Internal-combustion direct traction engines not exceeding 24 h.p., suitable for ploughing 2 furrows, 10 in. wide by 6 in. deep. Class 2: Internal-combustion direct traction engines, suitable for ploughing three furrows, 10 in. wide by 6 in. deep. Class 3: Internal-combustion direct traction engine over 30 h.p., suitable for ploughing four furrows, 10 in. wide by 8 in. deep. Class 4: Direct traction steam engine plant, suitable for ploughing four furrows, 10 in. wide by 8 in. deep. Engines to comply with the Light Road Locomotive Acts. Class 5: Internal-combustion double engine set, with wire rope haulage, for ploughing three or four furrows, 10 in. wide by 8 in. deep. Engines to comply with the Light Road Locomotive Acts. Class 6: Double steam engine set, with wire rope haulage for ploughing three or four furrows, 10 in. wide by 8 in. deep. Engines to comply with the Light Road Locomotive Acts. Class 7: Self-propelled plough for ploughing not more than four furrows, and not more than 10 in. wide by not more than 8 in. deep.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 5, at 6 p.m., adjourned Annual General Meeting; alterations of, and additions to, By-laws. Further discussion on "Recent Advances in Utilisation of Water-Power," by Mr. Eric M. Bergstrom, of London, Associate Member.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Saturday, March 6, at 2.15 p.m., in Room No. 1, Caxton Hall, Westminster, a paper by Mr. H. Kelway-Bamber, M.V.O., Member of Council, on "The Waste of Locomotive Power," will be read and discussed.

INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, March 6, at 4 p.m., in the College of Technology, Manchester, when Mr. A. C. Timmins, F.C.S., of Barrow-in-Furness, will read a paper on "Properties of Cast-Iron." Illustrated by lantern slides.

CLEVELAND INSTITUTION OF ENGINEERS.—Monday, March 8, in the Hall of the Cleveland Literary and Philosophical Society, Corporation Road, Middlesbrough, at 6.30 p.m. Paper by Mr. S. H. Fowles, on "Power from Blast-Furnace Gases."

THE BRADFORD ENGINEERING SOCIETY.—Monday, March 8, at 7.45 p.m., in the Hall of the Bradford Technical College, when a lecture will be given by Mr. R. L. Quertier, B.Sc., of London, on "The Use of Compressed Air in Industry."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Monday, March 8, at 8 p.m., a meeting of the Graduates will be held at the Institution, Storey's Gate. Paper, "British Association Threads," by Mr. T. F. Davey, of London, Graduate. Chairman, Professor W. E. Dalby, F.R.S., Member of Council.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Tuesday, March 9, at 7.30 p.m., Arts Building, Liverpool University, Mr. S. Clowes, Wh.Ex., on "Elementary Calculus," being the eighth lecture of the series. Thursday, March 11, at 7.30 p.m., The Grammar School, Chesterfield, Mr. Fred. Clements, M.I.Mech.E., A.M.Inst.C.E., Wh.Ex., on "The Principles and Design of Centrifugal Fans."

THE INSTITUTION OF ELECTRICAL ENGINEERS—SCOTTISH CENTRE.—Tuesday, March 9, at 7 p.m., Meeting in the Princes-street Station Hotel, Edinburgh. Paper: "The Protection of Alternating Current Systems without the Use of Special Conductors," by Major K. Edgcumbe, R.E.(T.), Member.

THE JUNIOR INSTITUTION OF ENGINEERS, NORTH-EASTERN SECTION.—Wednesday, March 10, at 7.15 p.m., Meeting in the Electrical Engineer's Lecture Theatre of Armstrong College, when Mr. Moncaster will read a paper on "Electricity for Heating."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, March 10, at the St. Bride's Institute. Paper, by Mr. L. Aitchison, D.Met., B.Sc., A.I.C., on "The Solidification and Crystallisation of Metals."

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, March 10, a paper on "Gas in Relation to Industrial Production and National Economy" will be read by Mr. Horace Moore Thornton, J.P. The chair will be taken at 4.30 p.m. by Sir Robert A. Hadfield, Bart., D.Sc., D.Met., F.R.S., Vice-President of the Society.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 11, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "Notes on Operating a By-Product Producer-Gas Plant for Power and Heating," by Mr. W. H. Patchell, Member; "Production of Power from Blast-Furnace Gas," by Mr. S. H. Fowles, Associate Member.

THE OPTICAL SOCIETY.—Thursday, March 11, at the Imperial College of Science and Technology, South Kensington, when a lecture will be given on "Hand-Signalling Lamps," by Mr. A. C. W. Aldis, M.A., of Birmingham. Members are invited to exhibit apparatus or other objects of interest to the society.

THE INSTITUTE OF METALS.—Annual General Meeting, on Thursday and Friday, March 11 and 12, in the Hall of the Institution of Mechanical Engineers:—Thursday, March 11: At 4 p.m., General Meeting of Members; the Report of the Council will be presented by the President; the Honorary Treasurer will present his Report; the new President will deliver his Inaugural Address. At 6 p.m., the Meeting will be adjourned. At 8 p.m. to 10 p.m., the Fifth Report to the Corrosion Research Committee will be presented and discussed. Friday, March 12: At 10.30 a.m., General Meeting of Members; a selection of papers will be read and discussed. At 1 p.m., the Meeting will be adjourned. At 2.30 p.m., General Meeting of Members, when further papers will be read and discussed. At 4.30 p.m., the Meeting will be brought to a conclusion. The following communications are expected to be submitted in the order given: (1) "Fifth Report to the Corrosion Research Committee," by Mr. G. D. Bengough, M.A., D.Sc., Member, Mr. R. M. Jones, M.Sc., and Ruth Pirret, B.Sc. (London); (2) "The Action on Aluminium of Hard Industrial Waters," by Mr. Richard Seligman, Ph.Nat.D., Member, and Mr. Percy Williams, B.Sc., Member (London); (3) "The Art of Casting in High Tensile Brass," by Mr. J. Neil MacLean (Glasgow); (4) "The Removal of Internal Stress in 70:30 Brass by Low-Temperature Annealing," by Mr. H. Moore, O.B.E., B.Sc., F.I.C., and Mr. S. Beckinsale, B.Sc., A.I.C. (Woolwich); (5) "Zinc Alloys with Aluminium and Copper," by Mr. W. Rosenhain, B.A., D.Sc., F.R.S., Vice-President, Mr. J. L. Haughton, M.Sc., Member, and Kathleen Bingham, B.Sc., Member (Teddington); (6) "A Model for representing the Constitution of Ternary Alloys," by Mr. W. Rosenhain, B.A., D.Sc., F.R.S., Vice-President (Teddington); (7) "Tin-Phosphorus Alloys," by Mr. A. C. Vivian, B.A., A.R.S.M., Member (London); (8) "Some Notes on the Effect of Hydrogen on Copper," by Mr. W. C. Hothersall, M.Sc.Tech., and Mr. E. L. Rhead, M.Sc.Tech., Member (Manchester); (9) "The Effect of Progressive Drawing upon some Physical Properties of Commercially Pure Copper," by Mr. W. E. Alkins, M.Sc., Student Member (Manchester); (10) "The Influence of Cold-Rolling on the Physical Properties of Copper," by Mr. F. Johnson, M.Sc., Member (Birmingham); (11) "The Study of Thermal Electromotive Force as an Aid to the Investigation of the Constitution of Alloy Systems," by Mr. J. L. Haughton, M.Sc., Member (Teddington); (12) Note on "The Polishing and Etching of Zinc for Micro-Examination," by Mr. H. H. Hayes, Member (Birmingham); (13) "Idiomorphic Crystals of Electro-Deposited Copper," by Mr. W. E. Hughes, B.A., Member (London); The annual dinner will be held at the Criterion Restaurant, Piccadilly Circus, W. 1, on Friday, March 12, at 7.45 p.m. for 8 p.m., under the chairmanship of Engineer Vice-Admiral Sir George Goodwin, K.C.B., LL.D.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 12, at 9 p.m., a discourse will be delivered by Mr. W. W. Rouse Ball, M.A. The subject is "String Figures." Afternoon Lectures, at 3 p.m.: Monday, March 8, Sir John Cadman, K.C.M.G., D.Sc., M.Inst.C.E., on (1) "Modern Development of the Miner's Safety Lamp"; Tuesday, March 9, Professor Arthur Keith, M.D., LL.D., F.R.S., F.R.C.S., M.R.I., Fullerian Professor of Physiology, on "British Ethnology: The Invaders of England" (Lecture II); Wednesday, March 10, Sir John Cadman, K.C.M.G., D.Sc., M.Inst.C.E., on (2) "Petroleum and the War"; Thursday, March 11, Lieutenant-Colonel Ernest Gold, R.E., D.S.O., F.R.S., on "The Upper Air (II)"; Saturday, March 13, Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., M.R.I., Professor of Natural Philosophy, on "Positive Rays" (Lecture IV).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 12, at the Junior Institution of Engineers, 39, Victoria-street, S.W. 1. Lecturette, "Chain Helico Pumps," by Mr. F. A. Simpson, Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 12, Informal Meeting. Subject: "Coating," introduced by Mr. A. J. H. Fitt, Associate Member.

UNIVERSITY COLLEGE ENGINEERING SOCIETY, UNIVERSITY COLLEGE, LONDON.—Friday, March 12, at 5.30 p.m., Annual Public Meeting in the Botanical Theatre at the College. Address by Sir Dugald Clerk, D.Sc., F.R.S., on "Coal Conservation." Visitors welcomed.

THE FORMATION OF SPUR WHEEL TEETH.—In accordance with a suggestion due to Sir James McKechnie, arrangements have been made for the delivery at the Barrow Technical School of a series of special evening lectures to apprentices. The second was delivered by Mr. J. Lewis, on Thursday, February 26, and dealt with the formation of wheel teeth. The speaker treated the subject for the most part historically, describing the various steps by which the present perfection of gearing as exhibited in motor-car practice and in turbine reduction gears had been attained.

THE LATE MR. WILLIAM RICHARDS WILLIAMS.—We regret to have to announce the death, which occurred on February 23, at Llyayronen, Fishguard, Pembrokeshire, of Mr. William Richards Williams, M.Inst.C.E., of "Baltynlass," Littlehampton, late of the Indian Public Works Department, and Inspector General Public Works Ministry, Cairo, Egypt. Mr. Williams was born on July 20, 1866, and in 1884 to 1887 he studied engineering at the Royal Engineering College, Cooper's Hill, subsequently becoming a Fellow of the College. In 1887 he was appointed assistant engineer to the Public Works Department by H.M. Secretary of State for India. He then served a practical course at Vyrnwy Waterworks under Mr. G. F. Deacon, chief engineer to the Liverpool Corporation. In 1888 Mr. Williams took up his appointment in India and from that year to 1890 he was employed on the construction of the Nadrai Aqueduct, Lower Ganges Canal. From 1890 to 1893 he was assistant engineer in the construction and maintenance of the Irrigation Works, Bhagnipur Division, Lower Ganges Canal. On his return to India, after eight months' furlough in 1893, Mr. Williams became assistant engineer-in-charge of the head works sub-divisions of the Upper Ganges Canal, considered one of the most important sub-divisions in the United Provinces. This involved considerable responsibility in the regulation of water and in the construction and control of large river and torrent-training works, &c. The period comprised the severe flood of 1894, including the "Golma" flood. In 1896 he was executive engineer-in-charge of the Anupshahr or Northern Divisions, Upper Ganges Canal, United Provinces, and between 1898 and 1899 he was appointed executive engineer-in-charge of the Special Works Division for the repairs to the large Narora Weir, Lower Ganges River. Mr. Williams then held the office of personal assistant to the chief engineer and under secretary to the Government Public Works Department for two years, ending April, 1901, when he was appointed to the Egyptian Irrigation service as inspector in charge of the 3rd circle of irrigation, Lower Egypt, under Mr. K. E. Verschoyle, C.M.G., Inspector General of Irrigation, Lower Egypt. He ultimately occupied the latter position. In 1906 Mr. Williams became a member of the Institution of Civil Engineers.

CYLINDERS OF 0-10-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE MIDLAND RAILWAY.

CONSTRUCTED AT THE COMPANY'S WORKS, DERBY, TO THE DESIGNS OF SIR HENRY FOWLER, K.B.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page* 311.)

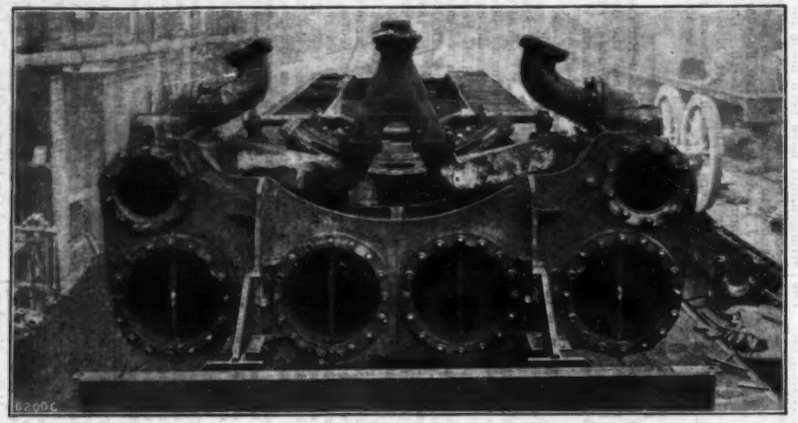


FIG. 12.

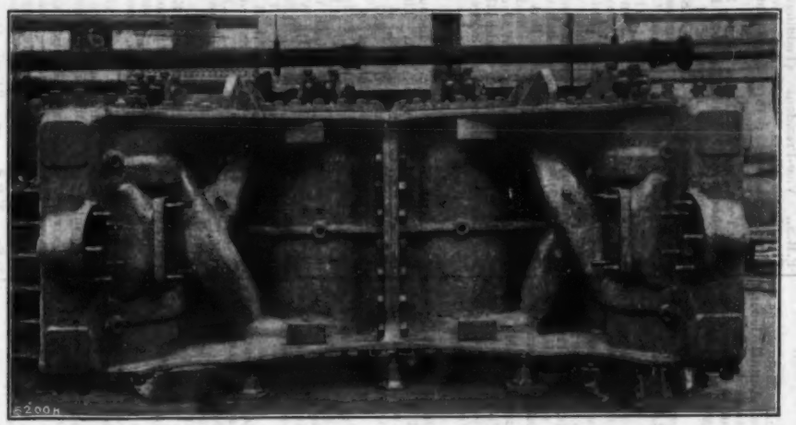


FIG. 13.

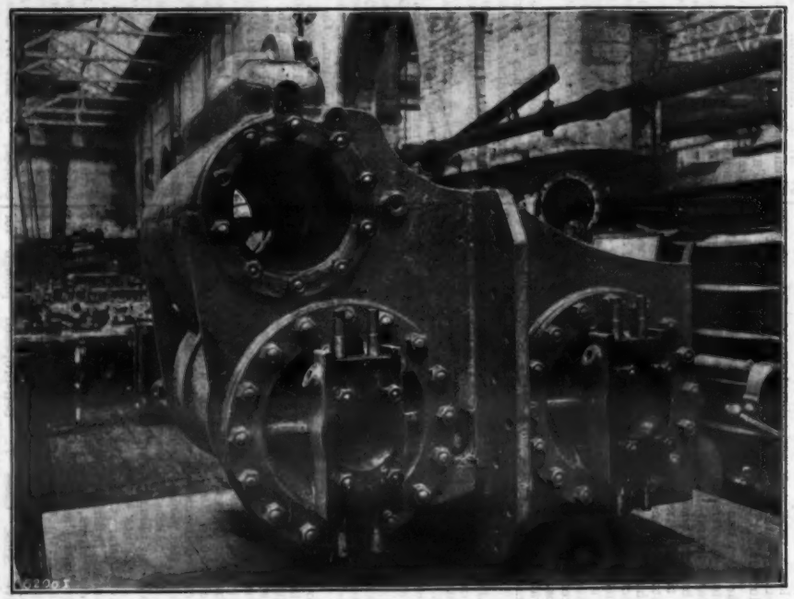


FIG. 14.

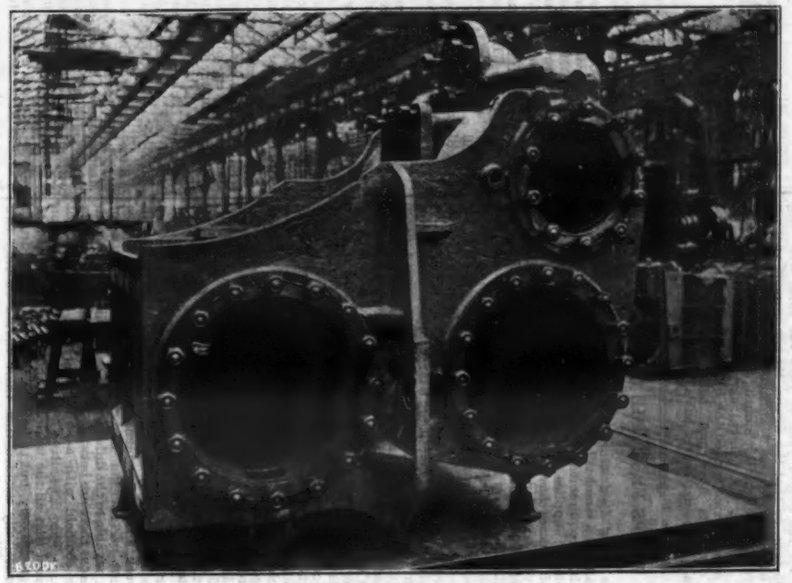


FIG. 15.

0-10-0 TYPE SUPERHEATER LOCOMOTIVE FO

CONSTRUCTED AT THE COMPANY'S WORKS, DERBY, TO THE DESIGN OF

(For Description, see P

Fig. 1.

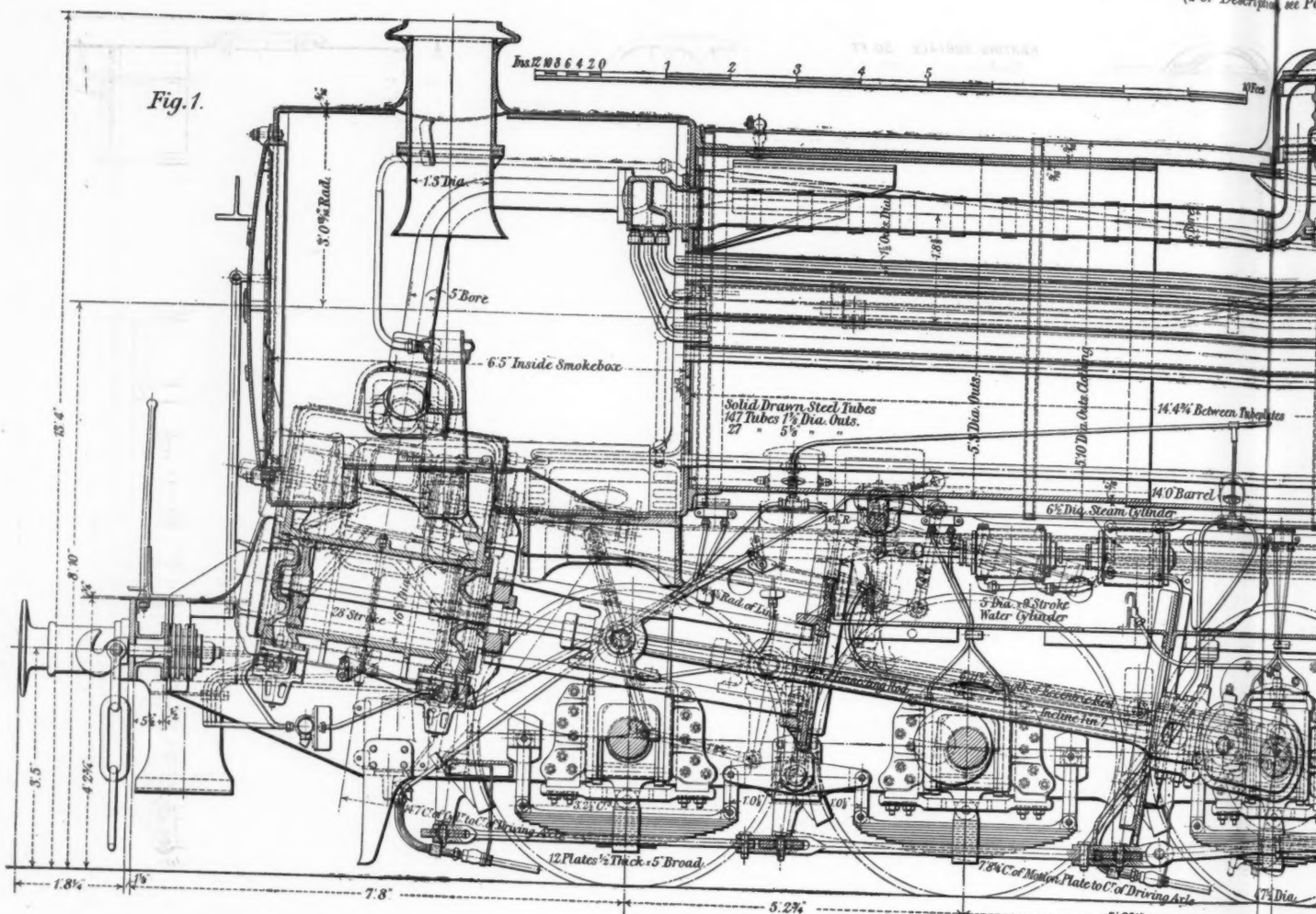
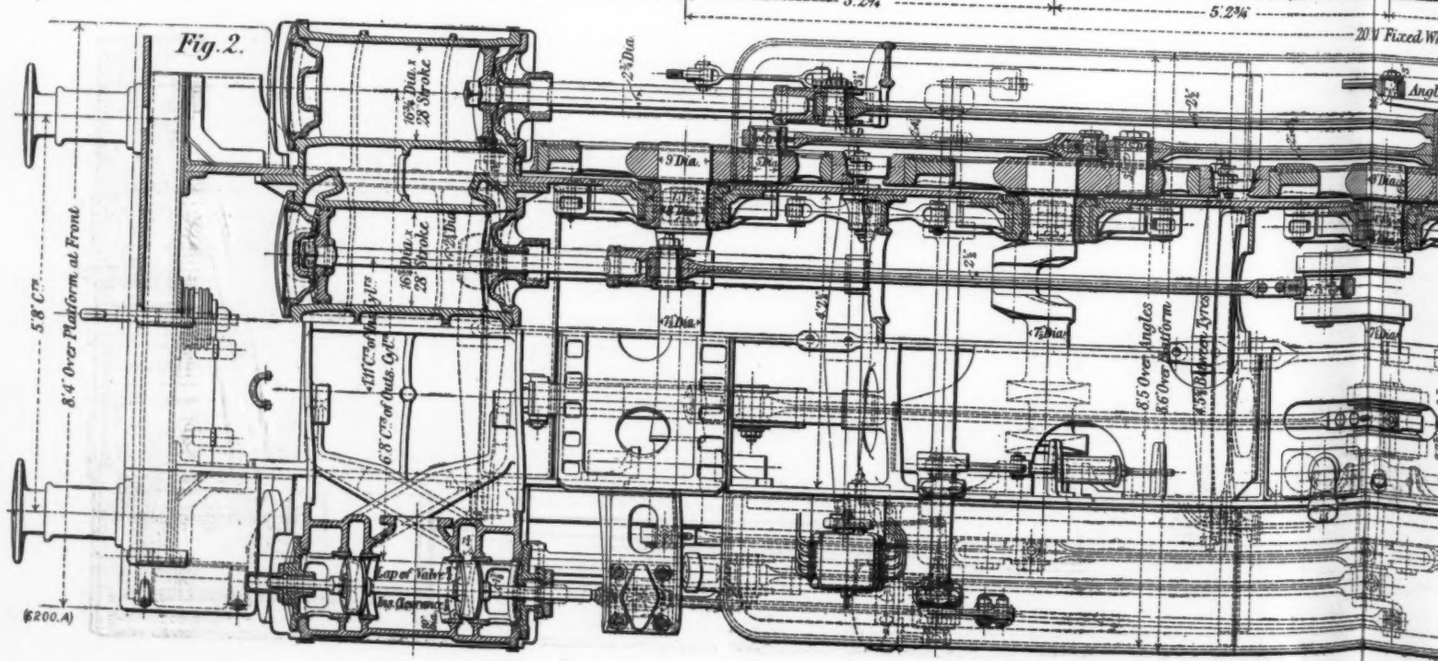


Fig. 2.



E FOR THE MIDLAND RAILWAY COMPANY.

SIGNS OF SIR HENRY FOWLER, K.B.E., CHIEF MECHANICAL ENGINEER.

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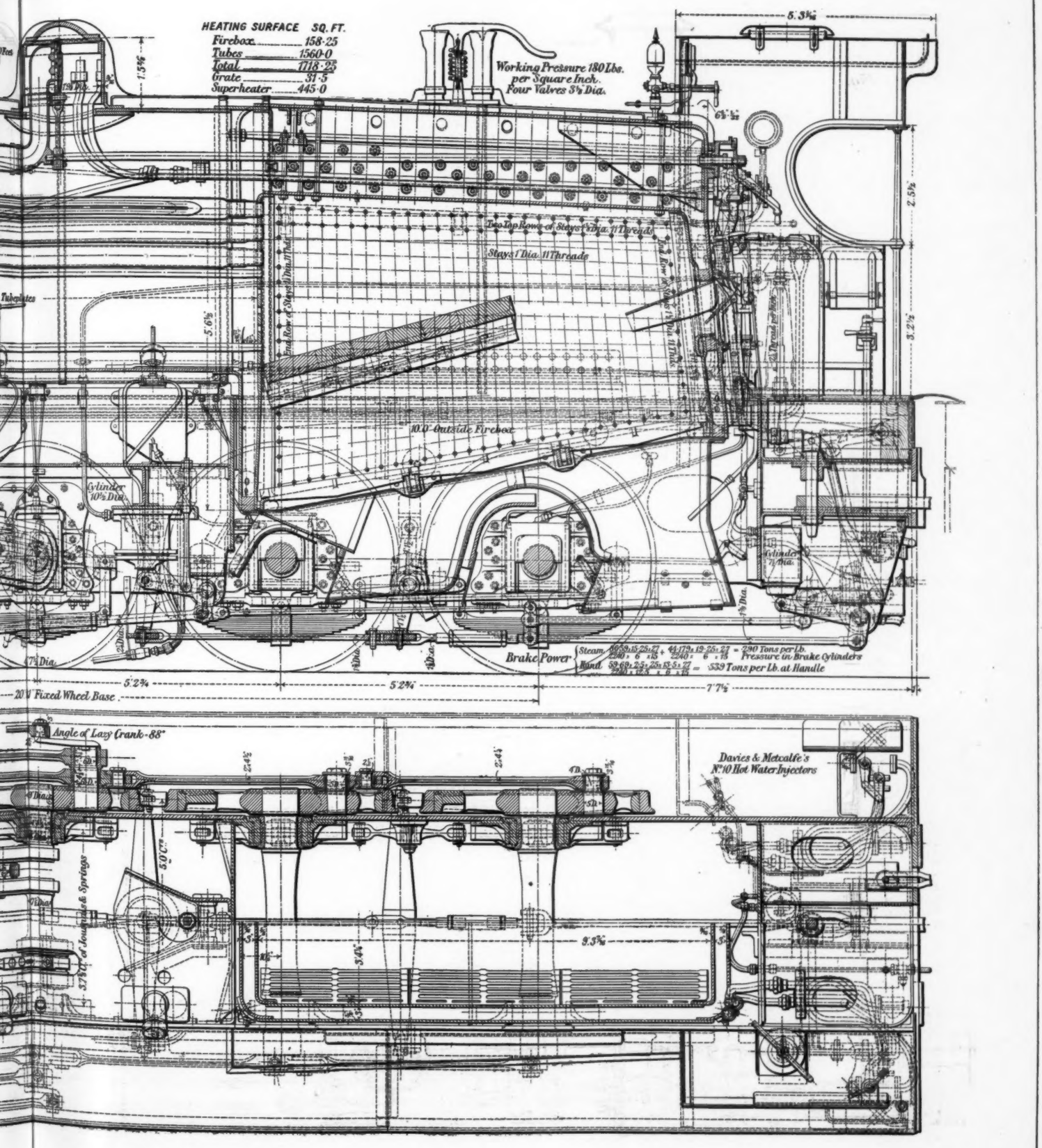
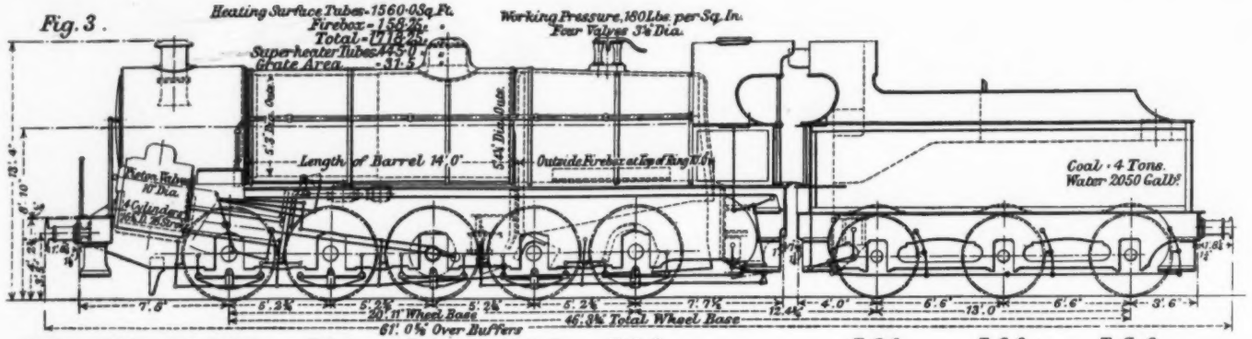

HEATING SURFACE SQ. FT.
Firebox 158·25
Tubes 1560·0
Total 1718·25
Grate 31·5
Superheater 445·0
Working Pressure 180 Lbs. per Square Inch. Four Valves 8½ Dia.
Two Top Rows of Stays 1" Dia. 11 Threads
Stays 1 Dia. 11 Threads
10·0 Outside Firebox
Cylinder 10½ Dia.
Brake Power
Steam 4658·15·25·27 / 2240 × 6 × 15 = 44·179 × 19·25 × 27 / 2240 × 6 × 15 = 2·90 Tons per lb. Pressure on Brake Cylinders
Hand 59·69 × 2·5 × 25 × 12·5 × 27 / 2240 × 12·5 × 6 × 15 = ·539 Tons per lb. at Handle
5'2¾
5'2¾
7'7½
20'0" Fixed Wheel Base
Angle of Lazy Crank-88°
Davies & Metcalfe's No. 10 Hot Water Injectors
5'0" Ctrs.
Springs
9'3½

0-10-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE MIDLAND RAILWAY COMPANY.

CONSTRUCTED AT THE COMPANY'S WORKS, DERBY, TO THE DESIGNS OF SIR HENRY FOWLER, K.B.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page* 311.)

Fig. 3.



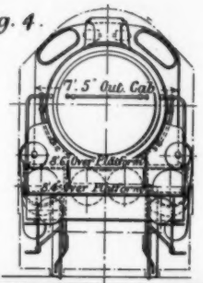
Weight in Working Order T. C. Q. 15. 8. 1 | T. C. Q. 15. 0. 0 | T. C. Q. 15. 10. 0 | T. C. Q. 13. 14. 3 | T. C. Q. 14. 0. 1 | T. C. Q. 10. 0. 3 | T. C. Q. 9. 18. 3 | T. C. Q. 11. 12. 0

Total Weight of Engine in Working Order - T. C. Q. 73. 13. 1 (6220. 0.)

Total Weight of Engine & Tender - T. C. Q. 105. 4. 3

Total Weight of Tender in Working Order - T. C. Q. 31. 11. 2

Fig. 4.



Tractive Power at 85% B.P.	43312 Lbs.	19·3 Tons
Adhesive . (Without Sand)	33148 .	14·8 .
. . (With .)	44713 .	19·9 .
Weight per Foot Run on Wheel Base		2·29 .
. . . . Over Buffers		1·74 .

(6200. E.)

Fig. 5.

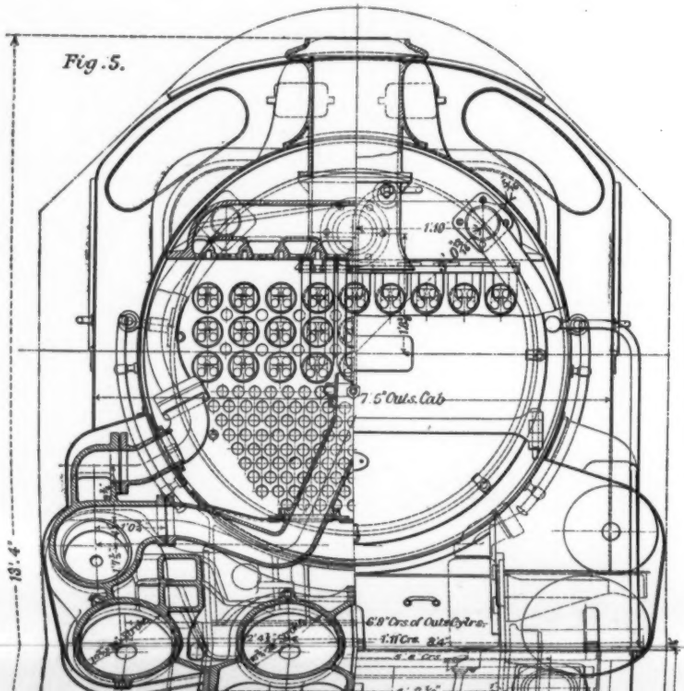
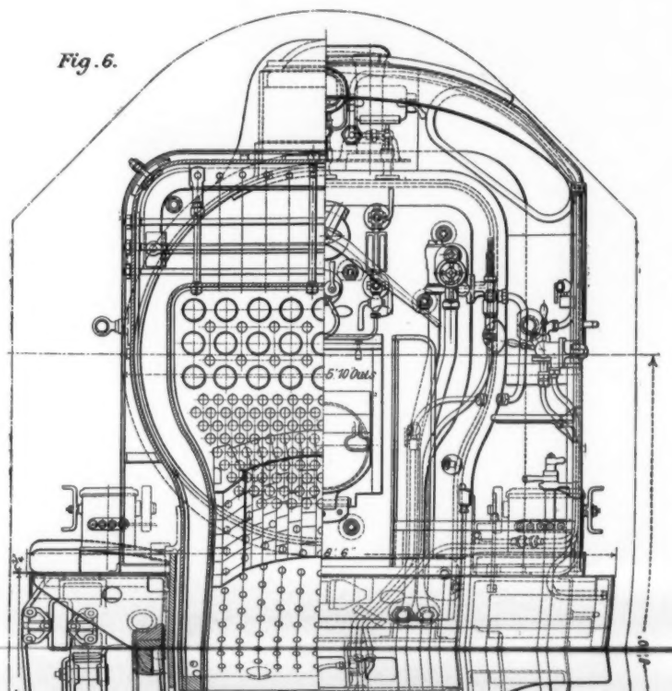
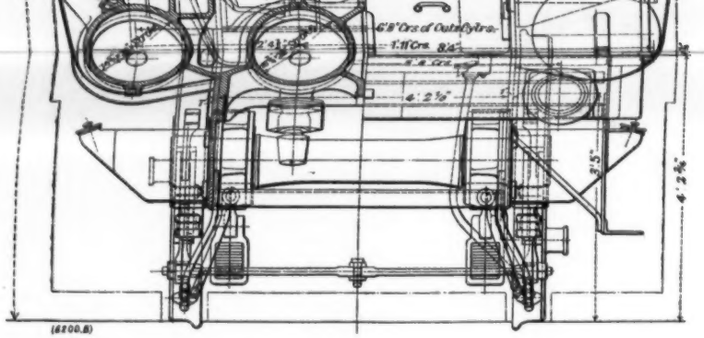


Fig. 6.





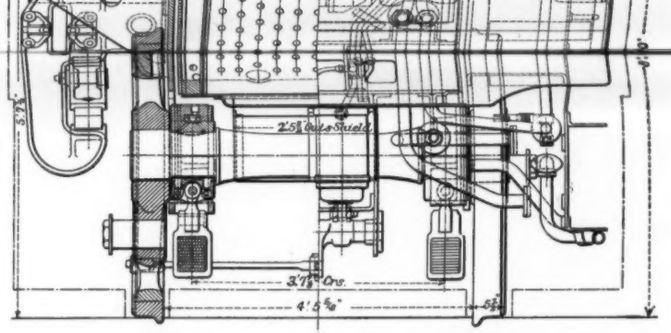
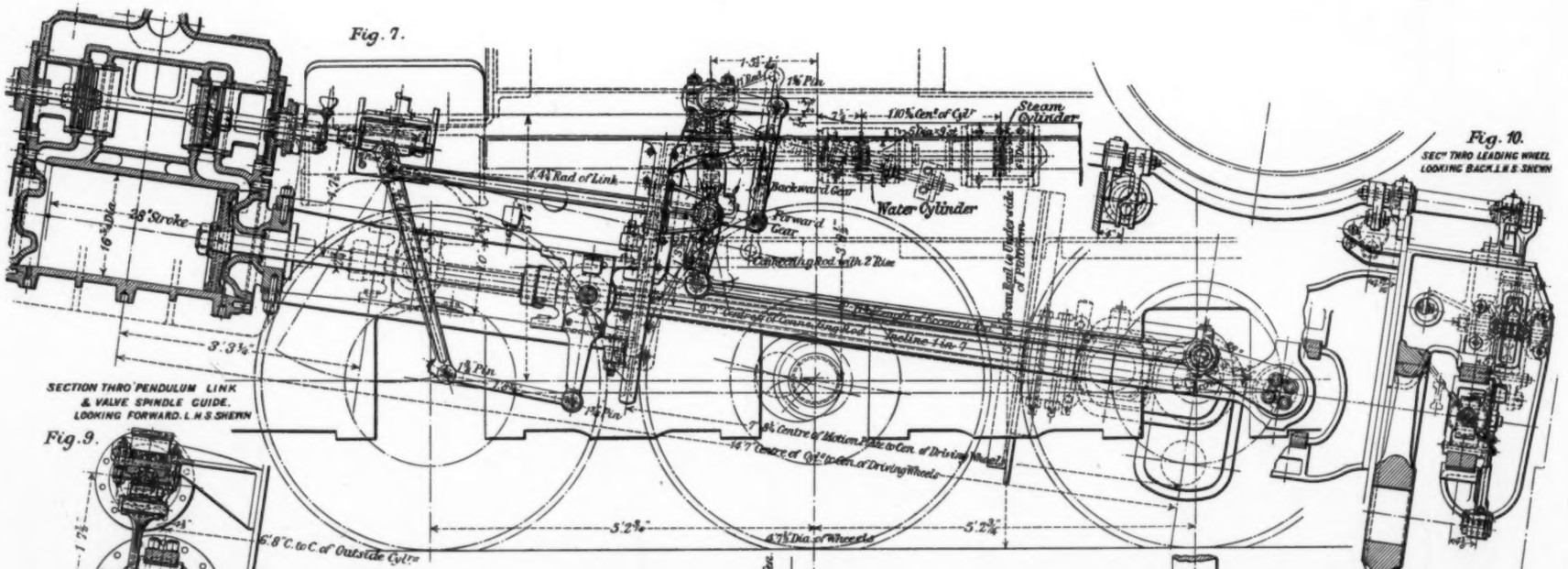


Fig. 7.



SECTION THRO' PENDULUM LINK & VALVE SPINDLE GUIDE. LOOKING FORWARD. L.H.S. SHEWN

Fig. 9.

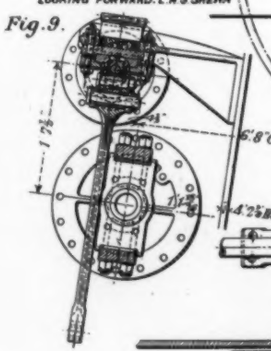


Fig. 8.

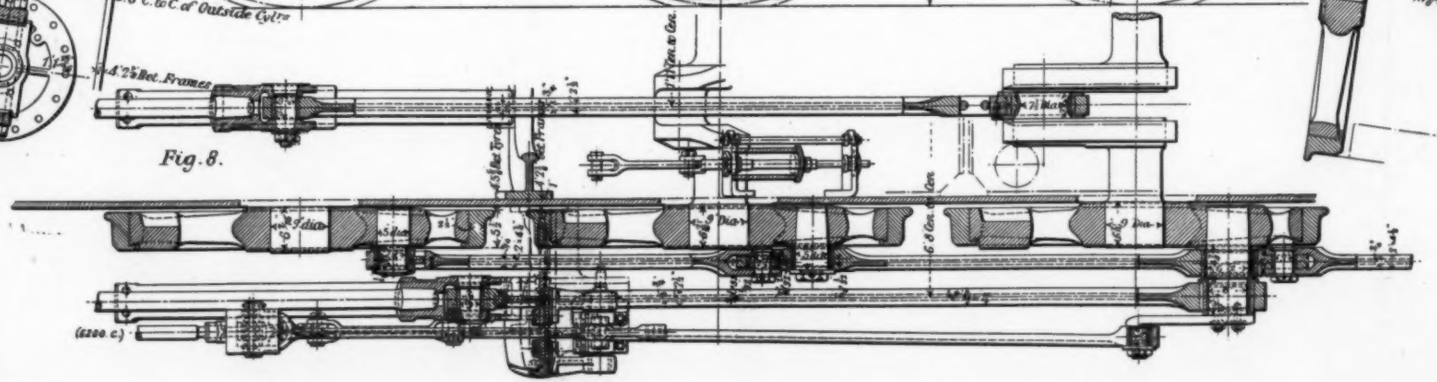
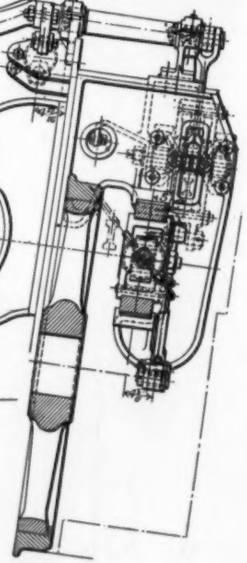


Fig. 10.

SECT THRO LEADING WHEEL LOOKING BACK L.H.S. SHEWN



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SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
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"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 3 0
For Canada—	
Thin paper copies	£2 18 6
Thick " "	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick " "	£3 7 6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 8708 GERRARD.

CONTENTS.

	PAGE
Literature	299
Books Received	301
A Steam Alignment Diagram (*Illus.*)	301
Management in Moderation	305
Rapid Railway Construction (*Illus.*)	306
Cold Metal Rolling Mills	307
Notes on New Books	308
Three Months' Fluctuations in the Prices of Metals	308
Marine and Stationary Internal-Combustion Engines (*Illus.*)	310
0-10-0 Type Locomotive for the Midland Railway Company (*Illus.*)	311
The Training of Shipyard Apprentices	311
Notes from South Yorkshire	312
Notes from the North	312
Notes from Cleveland and the Northern Counties	312
Notes from the South-West	313
Notices of Meetings	313
Current Generation for X-Ray Work	315
Water-Tube Boilers for Merchant Vessels	316
Magnetic Susceptibility	316
Positive Rays (*Illus.*)	318
The B.S.A. Tool Works at Sparkbrook	319
Notes	320
Industrial Notes	321
Flying Boats.—The Form and Dimensions of their Hulls (*Illus.*)	323
Metallographical Study on Galvanised Steel (*Illus.*)	327
ENGINEERING Patent Record (*Illus.*)	330

With Two Two-Page Plates of a 0-10-0 *TYPE SUPERHEATER LOCOMOTIVE FOR THE MIDLAND RAILWAY COMPANY.*

NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase dates from and includes the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

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In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 313.

ENGINEERING.

FRIDAY, MARCH 5, 1920.

CURRENT GENERATION FOR X-RAY WORK.

THOUGH the Röntgen rays achieved veritable triumphs during the war, and X-ray apparatus multiplied in numbers and uses to such an extent that a soldier left his hospital with a sense of injustice rankling within him, if his "picture" had not been taken, while even the engineer now examines the inside of his materials with the aid of the rays, the Röntgen bulb itself regarded as a scientific instrument has not received much systematic study and remains extraordinarily inefficient. By raising the potential applied to 200,000 volts we can increase the frequency of the radiations, and thus in a certain sense, the hardness and penetrating power of the rays, while reducing the wave-lengths to 0·02 Angström unit, that is, to less than 1/100,000 of the wave-length of visible yellow light. But we are yet far from approaching the shortest γ-rays, with which physicists and medical men would like to experiment, though it may require something like 2,000,000 volts to produce such radiations. We do not know how apparatus should be constructed for that purpose. Though everybody wants homogeneous rays, no bulb gives homogeneous rays, and all Röntgen tubes are exceedingly wasteful. The fact mattered little during the war, when economy was a secondary consideration. To judge by the lavish style of X-ray outfits it matters little even now, and X-ray equipments, portable or not, have indeed become so complicated and expensive that the current consumption is a minor item. But the inefficiency of the bulb is inseparable from other imperfections.

In the early days the Röntgen bulb was excited by an induction coil, and the coil was during the war first insisted upon by the military authorities and is still preferred by many workers. Nearly a dozen years ago Dr. H. Clyde Snook introduced a transformer outfit, consisting of a rotary converter, fed from continuous current mains (later replaced by a synchronous motor on alternating current circuits), a transformer receiving currents from the armature through slip rings, and a rectifier, generally a rotary disc with contact arcs. The Snook transformer does much, but it has not realised all expectations. Meanwhile the X-ray bulb itself had been improved and almost been reformed in 1913 by Dr. W. D. Coolidge, so that a general distinction is made between the old gas bulbs and the new Coolidge tubes. But neither radiographers generally nor therapists are satisfied with their current generation nor with the homogeneity and constancy of the rays and their effects. Some prefer coils, others transformers. They all want high potential; most of the workers agree that the wave-forms are the essential thing, but they are not certain about the milliamperes as to which the tubes are rated, or whether a coil and a transformer, apparently of the same potential and current, yield the same results. The physicist, medical man and manufacturer do not understand one another, and the engineer complains that they cannot tell him exactly what they want and demand things unreasonable. To promote co-operation the Institution of Electrical Engineers, the Röntgen Society and the Royal Society of Medicine (section of Electro-Therapeutics) held a joint meeting in the hall of the Royal Society of Medicine, on Thursday, February 26, the meeting occupying the afternoon and evening. The discussion of three papers practically might be summarised under the heading "Coil *versus* Transformer."

The trouble and want of understanding may largely be attributed to difficulties of measurements, partly due to want of co-operation of the experts, to whose number the photographer should be added. Dr. Reginald Morton, who has for years been prominent among X-ray investigators, remarked in his paper on the "Efficiency of High-Tension Transformers for X-ray Purposes," that "a 'soft' or low-resistance tube gave off very actinic rays of low penetration power. We could increase the penetration by raising the volts and also by using a 'hard' or high-resistance tube, but that was accompanied by an equal, if not more rapid, falling off of the actinism, plates obtained with hard tubes being of inferior quality and of little diagnostic value." That broad statement might perhaps be misunderstood. We cannot really say how far the blackening of the sensitised plate is a measure of penetration. The Röntgen Society recently appointed a committee to report on photographic densimeters and dosage, and that committee will not have an easy task. The penetrating power, as roughly understood, does not simply increase with increased frequency or reduction of wave-lengths. Our atmosphere is remarkably transparent to visible rays, but that penetrating power through gases is lost as we pass into the ultraviolet and beyond into the region of the Schumann and Lyman rays, which are stopped by a millimetre of air at ordinary pressure. To study those radiations we have hence to work in high vacua, as we have also in the case of waves longer than red light at the other end of the spectrum. But as we go further into the region of short waves, crossing from the Lyman rays *via* an unknown gap over to the γ radiations, penetrating power must generally increase again, not for gases only; for the swiftest γ-rays seem to be able to penetrate through all substances.

Now X-ray tubes give bundles of rays of various frequencies. X-rays are produced when the cathode rays or electrons hit an obstacle. In the old gas tube further electrons were generated by the electrons from the cathode striking the molecules of the residual gas. In the Coolidge tube the evacuation is so high that the residual gas is insufficient for the electron-supply; hence Coolidge combined the cathode proper with a spiral or filament of tungsten heated by a battery (with coil excitation of the tube) or by a branch from the transformer circuit, and he speeded up the thermoionic stream by applying high potentials to the tube terminals. The electrons strike the anticathode or target which emits the rays characteristic of the target metal, these being the swifter and harder the higher the atomic weight of the metal. So far as experiments go, the minimum potential required is in accord with the quantum relation. But physicists have hardly exceeded 200,000 volts, and Major W. G. C. Kaye, during the discussion, had good reason to criticise the inefficient, often childish, measurements on which many X-ray workers rely. Nobody actually measured the volts across his tube, Dr. Kaye remarked; their point spark-gap measurements might be wrong by hundreds per cent., and if the efficiency of the transformer came up to 90 per cent. or more, only 0·001 of that current went into the tube, and only 20 per cent. of the rays were really useful.

Even if accurate potentials and current measurements could be made on X-ray tubes—and they are made at the National Physical Laboratory, for instance—neither the coil nor the transformer would give homogeneous rays because the volts and amperes or milliamperes fluctuate. That, of course, is the importance of the current wave. Coils work with currents interrupted by rotary devices or simply by needles dipping into mercury (flash discharges), the currents being rectified. But the

rectification is not complete. The transformer gives more or less sinusoidal rectified current waves. Dr. Morton finds a potential curve rapidly rising to a high peak quickly dropping off again to a flat top most suitable. His curve thus resembles a house overtopped by a high chimney at the front end; the longer the house the more of the energy is undesirably spent in heating the tube. Most speakers agreed with him as to the advantages of some such curve, though not all shared his decided preference for coil working. Dr. Morton added an account of some quite recent experiments of his to his printed paper. He takes photographs of the discharge-impulse with the aid of a new device, a long wooden lath which is covered with sheet lead provided with a narrow cross slit over which the tube is placed. Underneath the lead is a tape of sensitised film which is pulled out so as to glide underneath the slit at rates up to 30 ft. per second. The impulse thus gives a dark line or band like a spectrum line, and these lines are sharper with coils than with transformers. When the tape speed is increased, however, the lines are seen to become multiple and successively fainter like the satellites of a spectrum line. The multiple character of the lines is due to current surgings in the condenser; but Dr. Morton was surprised to obtain as many as 10 broad bands with flash discharges in which the primary circuit may be broken at 80 amperes.

That the condenser is the weakest part of the coil outfit was pointed out by Major C. E. S. Phillips, of the War Office X-ray Laboratory, in his paper on "Problems of Interrupted and Fluctuating Currents." Dozens of coils were returned from France simply for defective condensers. Major Phillips remedied this defect by short-circuiting the condenser, best through three 16-candle 250-volt carbon-filament lamps, without appreciably reducing the output. The coil insulation had frequently broken down owing to fracture of the wax; Major Phillips suggested the use of a thin oil for insulation and drawing the oil off before transport. He also recommended aluminium wire for the secondary winding, removable coils and construction of the outfit in sections to facilitate transport; that had been German practice during the war. The mercury interrupters were another weak part. To avoid flare he would make the blades of tantalum which, though not wetted by mercury, gave a perfect contact. In order to study the behaviour of an in terrupter, a cup-shaped vessel closed by a membrane of rubber was screwed into the body of the apparatus; the pulsations of the gas in the cup were by a lever, resting on the membrane, recorded on a drum, and flaring was thus detected. In the interrupter Major Phillips further combines a valve cell (aluminium-lead) in series with a Wehnelt interrupter, the two being in shunt to the mercury cup interrupter; thus the current is made in the mercury, but broken in the Wehnelt cell, and by these means heavy currents can be worked by a tumbler switch. Preferring on general grounds the transformer, he suggested making the rise of the potential curve steeper on the plan proposed by Barr, Beeton and Taylor in the *Electrician* of June 21, 1895, by throwing with the aid of an "injector" (a commutator) inductance and capacity, or both, into the circuit; the injector might be keyed to a small synchronous motor in series to the mains and the transformer.

Mr. C. E. Clinker, M.I.E.E., who made some valuable suggestions during the discussion, thought the injector possible; he himself would put high density in the core and a high resistance into the secondary. To obtain high voltage in the transformer, he would start with alternating currents, not of the usual 50 cycles per second, but of 1,000 or 2,000 cycles, with the aid of thermoionic valves or of generators. How valves can be joined to transformer circuits had been sketched out by Professor Fortescue. Professor Fortescue's pertinent criticisms indicated that even the radio-telegraphist and the X-ray man work in separate compartments; radiologists and therapists did not appear to be familiar with the advantages of the valve.

The question of the apparent superiority of the coil over the transformer was definitely raised in the Röntgen Society eight years ago by Mr. A. E. Schall who showed that it requires more milli-amperes with a transformer than with a coil to produce the same photographic effect, and the point has been much discussed since. The meeting we notice thought it advisable to adjourn the discussion for further experiments. The coil is cheaper and, having no rotating parts, simpler. But Dr. Orton altogether questioned the superiority of the coil. Even the electric efficiency is not easily tested on strictly comparative lines. Professor Salomonson, of Amsterdam, communicated the results of some recent efficiency measurements of his, which were on the whole in favour of the transformer. That the further study of wave-forms in gas bulbs and Coolidge bulbs will be instructive was proved by the curves exhibited by Mr. J. S. Harlow.

We have to recognise the fact that several types of X-ray tubes may be wanted. The radiography of metals, wood, plants and living beings calls for different rays, and for deep radiotherapy medical men demand the swiftest rays and many hundred thousands of volts. Mr. W. E. Burnand, of Sheffield, asked in the course of his amusing, but apt remarks, whether the actual 10 ft. insulators of 200,000 volt apparatus were to be made 30 ft. high. As some of the high volts were only required for very short periods, he proposed to work a transformer excited by direct current, with an air gap in the magnetic circuit in which kilowatts might be stored for $\frac{1}{100}$ of a second. Perhaps humanity would be just as well off if medical men did not obtain their million-volt rays; the γ-rays of radium are sufficiently dangerous. But physicists will certainly go higher, and vacuum insulation may enable them to work with very high potentials.

WATER-TUBE BOILERS FOR MERCHANT VESSELS.

IN our issue of last week, page 294 *ante*, we reproduced a paper describing the "Standard" water-tube boilers adopted by the United States Emergency Fleet Corporation for wooden vessels. These boilers were adopted owing to the difficulty, under the circumstances then existing, of obtaining cylindrical boilers, and to the fact that the latter would have required much more material of a kind which was scarce at that time. A paper read before the Liverpool Engineering Society on Wednesday, March 3, by Mr. A. Spyer was mainly devoted to the description of the Babcock and Wilcox boilers, which were adopted under similar circumstances. The war has, in fact, resulted in the water-tube boiler being largely introduced into mercantile vessels, and this type will doubtless in time, now that it has secured so good a footing, gradually make sure its position in this class of shipping.

It is stated that during the past four years 782 ships have been ordered by the United States Shipping Board, fitted with 2,176 water-tube boilers. Of the types decided upon the Babcock and Wilcox boiler is represented on the larger number of ships. The American "Standard" boiler comes second. An interesting point, which reminds us that these orders were given with a view to the prompt commissioning of the ships, is the fact that in the Babcock and Wilcox boilers the tubes were 4 in. throughout, instead of in the usual British marine type, 4 in. for the fire row and $1\frac{7}{8}$ in. for the remainder. This was due to the fact that the manufacturing facilities were not available in the United States for producing marine type headers and the plant which usually turned out the land type headers (4-in tubes throughout) had to be utilised. The question of rapid production greatly influenced the decision with regard to these orders.

There is much to be said in favour of the water-tube boiler for mercantile vessels. Not the least advantage is a very appreciable saving in room and weight. Mr. Spyer gives the figures for two similar cargo boats on the Australian station in which, on 23,000 miles' work, the water-tube boiler vessel carried 20 per cent. more cargo on 9·8 per cent. less coal than the vessel fitted with cylindrical boiler. No information, unfortunately, is given as to whether the engine and auxiliary installations were comparable. In America, France, Spain, Holland &c., the water-tube boiler is gradually gaining ground for merchant service. It has been proved to be popular with the crew. Mr. Spyer cites a case in the cross-channel service in which, after experience with water-tube boiler vessels, it was found difficult to get the men to serve on others not so fitted.

The cross-channel service, while, of course, it has troubles of its own, is not affected by quite the same difficulties as vessels which have to keep at sea for several weeks. In the latter, questions of priming and fresh water feed are relatively more important than in steamers making short journeys; but as it is now recognised that even with cylindrical boilers these points deserve a good deal of attention, the water-tube boiler is at little, if any, disadvantage in this respect.

It is interesting to note that the American Babcock and Wilcox boilers are mostly oil fired and fitted with superheaters, whereas the British type are usually coal-fired and without superheaters. The water-tube boiler lends itself to effective superheating, but some form of by-pass control for the hot gases is necessary in order to regulate the degree of superheat. With the gradual introduction of the turbine the adoption of superheating will doubtless increase, retaining saturated steam for the auxiliaries, owing to lubrication difficulties. With regard to coal firing, Mr. Spyer is of the opinion that chain grate stokers will soon be introduced on water-tube marine boilers, and a test of this system of firing is likely to take place before long. To be used to advantage the system should in Mr. Spyer's opinion be combined with the bunkering of coal above the hopper level.

MAGNETIC SUSCEPTIBILITY.

WHEN recently writing on the magnetic and mechanical testing of iron* we referred to the singular character of magnetic phenomena, the real nature of which remains in many respects as mysterious as it was in remote ages. Professor Ernest Wilson, Dean of the Engineering Faculty, King's College, London, had also to speak of the mysteries of magnetism, when lecturing on "Magnetic Susceptibility," at the Royal Institution, on February 17 and 24. Practically only the metals of the iron group are considered magnetic. But nickel and cobalt rank far below iron, and the Heusler alloys, consisting of the three almost unmagnetic metals—manganese, copper, aluminium—are more strongly magnetic than nickel or cobalt. By alloying manganese with iron we can increase the very faint magnetism of manganese many times; but the iron has its magnetism reduced many times more strongly by being alloyed with manganese. Iron loses its magnetism at about 800 deg. C., nickel at 350 deg.; in an alloy of 30 per cent. of nickel and iron the magnetism disappears at 70 deg. and lower temperatures. Again, whilst iron is much more strongly magnetic than nickel, the order of the faint magnetism is reversed, Professor Wilson stated, in the solutions of their sulphates. In the case of the oxides of iron, the combination of iron with oxygen first decreases and then increases the magnetism; the intermediate oxide Fe_3O_4, magnetite, is very much more magnetic than either the ferrous or the ferric oxide, though the iron percentages do not differ very much. Similarly hematite is less magnetic than spathic iron, though richer in iron content.

In the case of the sulphides, the artificial FeS (obtained by fusing iron with sulphur) is more magnetic than the natural disulphide FeS_2, pyrites; when the latter is heated and loses part of its sulphur [under the formation probably of Fe_3S_4], the magnetism is intensified, as we should expect. In most cases, however, we are unable to account for the changes in magnetic properties which accompany chemical combination. We believe that bodies are built up of molecular magnets, oriented at random in non-magnetic substances, and more or less free to arrange themselves in magnetic fields so as to display external polarity; but the nature of that mobility is not understood.

Without discussing this last fundamental consideration, Professor Wilson defined magnetic permeability μ as the ratio of B/H magnetic induction to magnetic force, and the magnetic susceptibility k as I/H, ratio of intensity of magnetisation

* ENGINEERING, November 28, 1919, page 708, and also January 30 last, page 134.

to magnetic force,* and he dealt in his first lecture mainly with the susceptibilities of various metals, rocks and minerals and their measurement, and in the second lecture with the ways in which magnetic separators make use of the different susceptibilities of ores and gangues for effecting ore concentration. Like the permeability μ, the susceptibility k is by no means constant. It changes, apart from other influences, with the intensity of the magnetising force H and reaches, with iron and strongly-magnetic substances, its maximum value even in weak fields of a few c.g.s. units; but the maximum of k shifts, especially in faintly-magnetic substances, over into the region of higher magnetisation. When the magnetising force exceeds 500 c.g.s. units, however, all the curves practically become parallel and drop to low values of k. In crystals the k has different values along the different axes. We reproduce some of the figures from Professor Wilson's tables of the magnetic susceptibility k, giving only the volume susceptibility: the mass susceptibility would be obtained by dividing the respective figure by the density of the material. The figures are Professor Wilson's own work: Magnetite, 3 or 4 down to 1 and less; heated iron carbonate ore, 0·652; iron oxides, 0·007 to 0·0021; iron sulphide artificial FeS, 0·022, crystallised pyrrhotite 0·00575 to 0·00037 (varying with direction); chromite iron ore 0·001, chrome iron ore 0·00064; hematite, red and brown, 0·00073 to 0·00016; wolfram ore, 0·0003; tungsten metal, 0·000016; aluminium, 0·0000018; mica from Bengal, ruby and spotted with magnetite, 0·0147; grey granite, 0·001; dolorite, 0·0045. The following materials have a negative susceptibility: Water, 0·00000075; some glasses, 0·0000025 and less; copper, 0·00000073; antimony, 0·0000063; bismuth, 0·000014; for these substances the term $4\pi k$ in the general formula $\mu = 1 + 4\pi k$ has a negative sign. Though, as Professor Wilson pointed out, the different magnetites (the natural loadstones) varied very much as to their k, the curves had mostly the shape of the pure iron curve, which has a sharp peak at low magnetising force, attaining a maximum k value of 400, while in the best Traversella magnetite the k limit of 3 or 4 is not exceeded (k being 3·12 at a force of 13 c.g.s. units, *e.g.*). The k curves of the impurer magnetites and of the New Zealand iron sands (0·28) are much less peaked, and the indistinct maxima attained at much higher magnetising forces (*e.g.*, $k = 0·127$ at 368 units). We have referred already to manganese steel. Manganese itself has a k of 0·000084; a 13 per cent. manganese steel from Messrs. Hadfield resembled some of the magnetites also in so far as prolonged heating (for 100 hours) to 530 deg. C., while destroying the magnetism as long as hot, left the steel with a higher k (0·54, against 0·0004), and an increased coercive force and residual magnetism after cooling. Some ores were thus improved by heating, others deteriorated magnetically. As regards sulphides the following values of k, first determined by Professor Wilson, are of considerable interest: artificial iron sulphide, 0·022; pyrites, cubic, 0·000151; rhombic, 0·00021, after heating, 0·00255. Sulphides of other metals were also measured. Prof. Wilson has examined a great many rocks and minerals in connection with the magnetic survey of the United Kingdom, and he described the instruments he uses for these measurements.

Ballistic methods and magnetometers not being generally suitable for measuring small susceptibilities below 0·001, Prof. Wilson modified the magnetic balance of the late Prof. Curie in two ways. In his portable balance a horizontal beam is supported by a phosphor-bronze strip from a torsion head. The specimen hangs at the one end of the beam, which is counterpoised at the other, between the pole pieces of a cylindrical ring magnet of peculiar construction. There are two rings of tungsten steel, resting upon one another like sections of the same cylinder. The upper ring can be turned about its vertical axis. Each ring is so magnetised as to have the two poles at the ends of a diameter, and the similar poles may either be superposed or be at various angles to one another. By varying the azimuth the strength of the field can thus be changed. The horizontal pole pieces are arranged along a fixed diameter of the ring, *i.e.*, they remain stationary when the upper ring is turned, and there is a central pole gap of 1 cm. or 2 cm. When the torsion head is turned and the strip twisted, the specimen at the end of the beam would swing out of the pole gap if it were not held back by the magnetic lines of force crossing through the specimen between the two pole pieces. When the torsion angle θ becomes too great, the specimen breaks away. That angle θ is observed, and k is deduced from Maxwell's formula,

$$F = \tfrac{1}{2} k d H^2 / dx,$$

where F is the mechanical force per unit volume, H the magnetic field, and x the distance. If the volume be V, then $k = C\theta / H^2 V$, where C is the constant of the instrument.

In the more sensitive laboratory type of the balance the horizontal permanent ring magnets are replaced by an electromagnet placed vertically which has its pole gap above, thus resembling a vertical horseshoe of ring shape. The specimen is again suspended from a beam, but the torsion is not measured, and the instrument works in a different way. Instead of twisting the beam wire, the ring magnet is moved to and fro, towards the observer or away from him, with the aid of a screw, the magnet traversing on horizontal guides. When the current of the electro-magnet is turned on, the magnet is first moved towards the observer. The specimen follows the magnetic pull until the opposing mechanical pull becomes too strong, and the specimen swings back. This movement is watched with the aid of a bright spot reflected from a small mirror attached to the beam suspension wire; as the magnet is sliding, the spot is more and more deflected to the left, *e.g.*, until it suddenly returns to zero. The operation is then repeated, moving the magnet in the opposite direction; the light spot travels to the right, until it breaks away again. Curves are thus obtained for different magnetising currents, and from these the susceptibility range is deduced.

The pole gaps were made sufficiently wide in these balances, Professor Wilson explained, to take the specimens applied in the shape of cylinders, or, if powdered or in solution, contained in short glass tubes. Longer specimens would be preferable to reduce the end effect, viz., the demagnetisations caused by the mutual action of the poles upon one another when not far apart. For that reason the ordinary magnetometer method, deflection of a suspended magnetic needle by the specimen, direct or when magnetised by a coil surrounding it, was generally not suited, especially with very feeble magnetisation.

In such cases the ballistic method could be used. The electro-magnet in that apparatus formed a horizontal ring, the pole gap of which was ordinarily bridged by a rod of wood surrounded by the bobbin of an exploring coil in circuit with a galvanometer. On closing the magnetising circuit the galvanometer gave a kick in one direction, and, on reversing the current and field, a kick in the opposite direction. The piece of wood was then replaced by the specimen, and the kicks were again observed. From the ratio of the kicks the required susceptibility could be deduced.

Passing to magnetic separators, Professor Wilson said that, though W. Fullerton patented a separator in 1792, the first actual use of magnets (revolving) for the separation of magnetite from pyrites seemed to have been made in Traversella in 1858, and the real development of magnetic separators in Scandinavia dated only from about 1880. In quite recent years the development had been remarkable. From figures given by Professor H. Louis at a Paris Conference last spring it would appear that Norway treated, in 1912, 750,000 tons of ore magnetically, when Sweden and the United States dealt only with about 300,000 tons each. By 1914 Norway had gone up to 2,200,000 tons at Sydvaranger (Gröndal machines), the United States by 1916 to 1,200,000 tons in the Minneville mines, N.Y. (Ballard Norton machines), Sweden by 1917 to 2,500,000 tons. The separation was generally twofold. The ore was first broken up to lumps of about 2 in., which were separated, and this first concentrate was then ground fine and again separated. Magnetite was mainly associated with iron pyrites, apatite (calcium phosphate) and felspar. The two latter minerals were very feebly magnetic, but the trouble with apatite was that it was very intimately mixed with the magnetite, and that phosphorus had to be kept out of the iron as much as possible. The separation might be in the dry or in the wet. For the first coarse separation horizontal drums of the Wenström type were used. The cylindrical shell of this drum, about 2 ft. in length and diameter, was built up of horizontal bars of wood and iron, the latter of alternating polarity, the magnetising devices being inside the slowly-revolving drum. The lumps clung to the iron bars. In the Gröndal drum parts of the circumference were magnetised by four pairs of radial internal electro-magnets; the shell was of brass. The ore travelled on a belt round the drum and was held there by the attraction. The Ball-Norton machines were of a similar type. The separation of the finely-powdered or grainy material was effected on similar lines, or on the principle that a stream of magnetic powder issuing from a funnel or hopper and falling past a strong magnet would be deflected by the magnet, whilst the gangue remained undeflected. Edison arranged three or more electro-magnets above one another, the pole piece in each case projecting from the lower end of the magnet. Such arrangements did not effectually remove the apatite, however, even when the stream was crossed by an air blast. Gröndal hence adapted his drum to a wet treatment. The powdered ore dropped into a water tank and was stirred up and raised over a weir up to the revolving drum, which dipped into the water. The adhering magnetic material was washed off again by a spray of water and delivered into a second tank for renewed separation.

None of these separators were able to deal with the feebly magnetic materials to be separated in the concentration of monazite, the raw material for the thoria-ceria mantles. The three chief minerals to be separated there, ilmenite (black sand), monazite and zircon, had the susceptibilities 0·00147, 0·00069, 0·0000005. They were successfully treated, both in the coarse and fine conditions, by the machines of the Humboldt Company, and also by the Rowand-Wetherill machines which Wetherill first devised in 1896 for separating zinc ore from franklinite. In the latter the powdered or grainy material was fed on a horizontal belt travelling over two pulleys; above and across the belt were fixed two pole pieces with knife edges, the flat corresponding poles being below the belt; the pole gaps were thus vertical, and the first gap was wider than the second. The first weaker field picked up the ilmenite, the second stronger field the monazite; both the particles adhered to the lower surfaces of cross bands traversing between the poles and the belt. The British Rapid machine acted on a somewhat similar principle; there were three rotating bell-shaped magnets at different distances above the belt, and the picked up material was thrown off again by centrifugal force. The last Ullrich machine which Professor Wilson mentioned tries to overcome one of the chief difficulties of the wet Gröndal machines, that the magnet has to drag the particles out of the water against the pull of the surface tension. Ullrich lets the powdered material glide down a belt resting on an inclined plane resting on the one pole system; above it are mounted the other concentric rotating ring poles, ending in knife edges. Water streams down over the outside of the steel rings, and the magnetic particles run up the water curtains and are retained by the pole pieces.

Professor Wilson did not enter into technical details nor into the cost question. It is well known that heavy failures of magnetic separator plants have to be booked against the successes realised in other instances. More than previously, the future development of magnetic separation will go together with concentration by gravity and by flotation, all supplementary to one another. The present tendency is evidently towards perfecting concentration so as to feed as pure a material as possible into the melting furnace.

* For definitions we would refer our readers to our article on page 708 of our issue of November 28 last.

POSITIVE RAYS.

On Saturday afternoon last Sir J. J. Thomson, O.M., Pres.R.Soc., delivered at the Royal Institution the second lecture of his course on Positive Rays.

The lecturer said that on the previous occasion he had shown that positive rays affected certain substances which were caused to phosphoresce at the point struck. This phenomenon provided means by which the path of the rays could be traced. It was, however, desirable for the purpose of accurate measurement to employ not this transitory luminosity but some permanent record of the path traversed by the rays. Fortunately these rays affected a photographic plate at the point they struck and, as it were, photographed themselves there; leaving a record which could be measured with accuracy and kept for reference. The problem of photographing these rays differed, however, from that of ordinary photography, the effect being due to the impact of charged particles and not to the action of light. In ordinary photography the light traversed the whole thickness of the film, thus

FIG. 1.

FIG. 2.

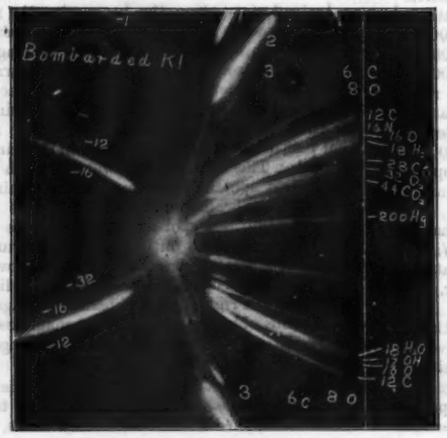


FIG. 3.

utilising the whole of the silver there. In the case of positive rays the effect of the colliding particles did not penetrate into the film to an appreciable extent, and, in fact, the layer altered by the impact was so thin that an American observer had found it possible to wash away all trace of positive ray action by immersing the plate in water and going over the surface with a camel's hair pencil. By this simple process the whole of the record could be removed. It followed accordingly that if ordinary plates were used for taking positive ray photographs, by far the larger proportion of the silver in the film was wasted. What was required, in short, was a plate having a very thin film but containing a large quantity of silver.

At one time the speaker had thought that the old method of photography on a silver plate, sensitised by exposure to iodine vapour, should be ideal for positive ray work, but the experiment did not prove very successful. After prolonged investigations in which most makes of plate in the market were tried, he had found that the best results were obtained either with Paget process plates or with what were known as Schumann plates. The latter had been originally produced for one definite purpose. Included in the spectrum were certain rays which lay so far beyond the ordinary ultra violet rays that they might be called super ultra violet rays. These rays were absorbed with the greatest avidity by almost every substance. They could not pass through more than 1 mm. or 2 mm. of air at its ordinary pressure and were absorbed by the gelatine film of a photographic plate so quickly that the light never reached to the back of the plate. Hence the problem of photographing these rays was in some respects analogous to that of positive ray photography. Since these plates were now on the market they might conveniently be adopted for the latter purpose. They had, however, one remarkable peculiarity. Freshly made, they were useless, and they were again no good if too old. So that it was necessary to know their age if they were to be employed with safety.

As to whether preference should be given to these plates or to the Paget process plates depended upon the object in view. The process plates had a very fine grain and gave very sharp images easier to measure and in every way more tidy than those obtained with the Schumann plates. Thus Fig. 1 had been taken with a Paget process plate and Fig. 2 with a Schumann plate, the conditions being otherwise identical. In Fig. 1 the outermost curves had been made by the impact of atoms of hydrogen and the next curve by molecules of H. Then came curves corresponding to carbon, nitrogen and oxygen. Some of the atoms of carbon, oxygen and nitrogen were, it turned out, carrying double charges. This was, however, better seen in Fig. 3, where the curves marked 8 O and 6 C corresponded to atoms carrying double charges and the curves lettered 16 O and 12 C to atoms carrying a single charge. There was, moreover, a faint line on the plate (not visible in the reproduction) which appeared to correspond to a new substance having an atomic weight of 3½, of which the speaker would have more to say on another occasion.

As would be seen, all the lines in Fig. 1 were sharp, well defined, and could be easily measured.

In the case of the Schumann photograph, Fig. 2, the lines were much thicker, the impression made by the impacting particles having spread sideways, and to that extent the traces on these plates were more difficult to measure. One line in Fig. 3, it might be added, was apparently due to a molecule consisting of three hydrogen atoms. Some of the traces, it might be noted, showed signs of solarisation or reversal due to over-exposure.

It was evident from these records that an enormous number of particles took part in carrying the charge and he would, the speaker proceeded, now explain the means used to sort out these particles into their different kinds. To this end advantage was taken of the fact that these rapidly moving charged particles were acted on by electric and magnetic forces. Heavy particles were less deflected than light ones, and thus if a mixture of these charged particles were sent through a magnetic field the light ones would be most deflected. Thus if A, Fig. 4, represented a tube through which the particles were passing, then in the absence of deflecting forces the target would be struck at B. If, however, a magnetic field were established across the path at H perpendicular to the plane of the paper, the particles traversing this field would be swung through circular arcs as indicated, and on leaving the field would proceed along the tangents to these arcs striking the target accordingly at points such as C. or D. The lighter particles being swung through the sharpest curve would be thrown up to a correspondingly greater extent. Were all the particles moving with the same speed, this process of sorting out a mixture by means of a magnetic field would be quite satisfactory. Unfortunately, however, the effect of the magnet depended not merely on the mass of the particle but also on its speed. Slowly moving particles were more deflected than those moving more quickly, so that a light quickly moving

Fig. 4.

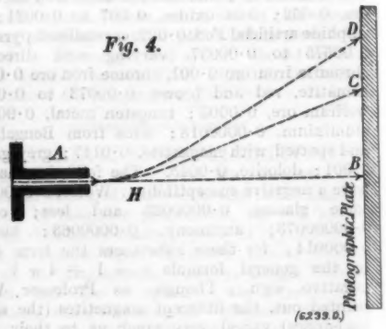


Fig. 5.

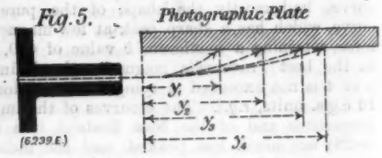
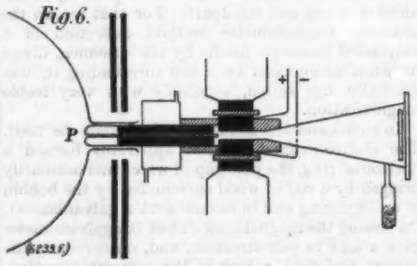


Fig. 6.



atom might strike the target in the same place as a heavy slowly moving atom. The deflection produced by the magnetic field was, in fact, proportional to the quantity $\frac{e}{m\,v}$ where e denoted the charge carried m the mass and v the velocity of the atom. Hence two atoms for which the product $m\,v$ was the same would be equally deflected. The result, therefore, of subjecting the positive rays to a magnetic field only, was a photograph showing a continuous ribbon in which it was impossible to distinguish the traces due to different atoms. This muddle was rectified by applying to the stream of particles an electric field in addition to a magnetic field, matters being so arranged that the deflection produced by the electric force was at right angles to that due to the magnetic forces, so that if the latter moved the particles vertically the electric force shifted them horizontally. The faster particles were deflected by the electric field less than the slower ones, and the result was that we got on the photographic plate a series of curves such as those visible in Fig. 1.

The deflection produced by the electric field was proportional to $\frac{e}{m\,v^2}$, and that due to the magnetic field to $\frac{e}{m\,v}$, as already stated. Hence if y denoted the deflection due to the magnetic field and x that due to the electric force the equation to the curves on the plate should be

$$y^2 = C\,x\,\frac{e}{m},$$

where C denoted some constant. In other words the curves were parabolas. From this relationship the atomic weights of the particles which photographed themselves on the plate could be deduced. Thus, if we drew a vertical line on the plate for

which line x was constant, we had the rule that the mass of a particle was inversely proportional to the square of its magnetic deflection. Hence if the outermost curve were considered as due to the H atom then a curve in which the magnetic deflection was half as much would be due to a particle having four times the mass of hydrogen which was helium.

The disadvantage of the method lay in the fact that the curves corresponding to the different atoms all lay between that due to the hydrogen atom and the horizontal axis of the figure. Hence the curves representing bodies of high atomic weights were crowded together close to the horizontal line and could not readily be scaled.

Another method of determining atomic weights from these photographs was to draw horizontal lines across the curves. In this case y was constant so that x was proportional to the mass of the atom responsible for a curve. Equal distances measured horizontally across the plate corresponded, in fact, to equal increments of atomic weight. The scale was more open than when vertical measurements were made, but there was the drawback that any horizontal line only cut a few of the curves, and hence to measure up a whole series a step by step

FIG. 7.

FIG. 8.

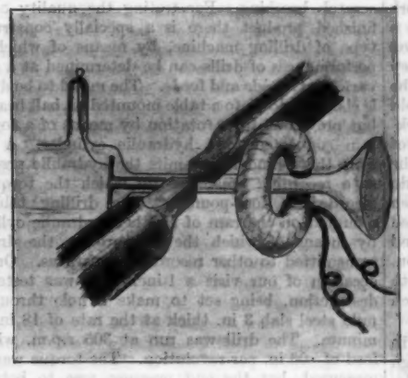


FIG. 9.

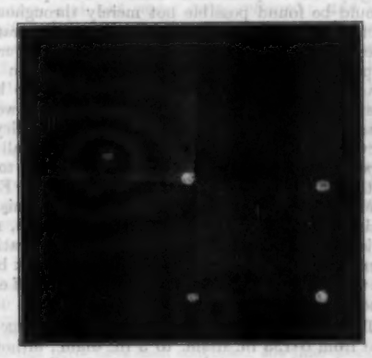


FIG. 10.

procedure had to be employed. There was still another method of getting a more open scale. In the arrangement indicated in Fig. 4 the photographic plate was placed vertically. It could, however, be placed horizontally, as indicated in Fig. 5. In that case the curves obtained were such that the distances y_1 y_2, &c., were proportional to the square roots of the masses of the particles. The scale was thus much more open than when the plate was vertical, but there was the disadvantage that the positive rays struck the plate very obliquely and the curves registered were accordingly not quite so well defined.

The apparatus actually used in the speaker's investigations was represented diagrammatically in Fig. 6. Here P denoted the cathode, which consisted of a perforated tube. This tube constituted the most critical part of the whole apparatus, and ought to be only a small fraction of a millimetre in diameter. In the past, the speaker had used the point of a hypodermic syringe, but this was not satisfactory. He now took the finest copper tube obtainable and rolled it out until the bore was not more than $\frac{1}{10}$ mm. in diameter. He might add in passing that the rays wore away the tube somewhat rapidly, much as a sand-blast might do, making a sensible reduction in its length in the course of a few days' use. The positive rays, after passing through strong electric and magnetic fields, strike the plate shown on the right, and make their record there. In order to get good results, a careful adjustment of the pressure inside the apparatus was necessary. If this pressure were too low in front of the cathode (*i.e.*, on the left of the figure), no discharge would pass, whilst, unless it was very low on the right-hand side of the apparatus, the positive rays would have difficulty in getting through the gas. These apparently incompatible conditions were met by the use of a tube of very small bore as the cathode, and connecting up the right-hand side of the apparatus with a bulb containing charcoal, and immersed in liquid air. Owing to the fineness of the connecting tube between the left-hand and right-hand portions of the apparatus, the air leakage from one compartment to the other was so small that the chilled charcoal absorbed it as fast as it came through, so that a very high vacuum could be maintained in the right-hand compartment; although the pressure in the left-hand compartment was reasonably high. With a low pressure on the right-hand side, the curves recorded were well defined, as in Fig. 7, where the trace had been made by the mercury atom. On the other hand, the fuzzy record reproduced in Fig. 8 showed the kind of trace obtained when the pressure was the same on both sides of the apparatus. This was the kind of effect observed when work was first started on these positive rays. According to the theory, the curves ought to have been parabolas, but owing to the gas pressure being too high, the trace was actually as shown. Remnants of similar straight line traces were to be seen in Fig. 2. The way in which these originated was very interesting. They depended on the fact that when a positive ray passed through a gas it was repeatedly losing or gaining a charge, and thus did not remain positively charged throughout its whole path. In fact, it might even acquire a negative charge under such conditions. That charges were lost and gained in this way could be demonstrated by the apparatus represented in Fig. 9. Here the positive rays were passed through two magnetic fields in succession, arranged at right angles to each other. Now, if a particle remained charged during its passage through both fields, the deflections due to each would merely be added together, and the effect of the second field would merely be to shift the position of the spot on the screen. If, however, after passing through the first field, a particle lost its charge before reaching the second, it would suffer no further deflection in this and would strike the screen in the same spot as if the second field were absent. Similarly, a particle uncharged, whilst passing through the first field, and charged in traversing the second, would be deflected by the latter only. Hence, if particles lost and gained charges, the effect of subjecting them to the influence of two successive magnetic fields would be to increase the number of spots visible on the screen. This was found to be what actually happened, as represented in Fig. 10. Here one spot was due to particles which were uncharged in passing through both fields, whilst the other three originated as above explained. Here, then, was direct evidence that the particles did lose and gain charges on their passage from cathode to target.

When the positive rays had to pass through a gas at other than an extremely low pressure, certain of them were only charged for a very small portion of the time during which they traversed the electric field, and were, therefore, not as much deflected as those charged the whole time. As the proportion of time grew longer, the deflection produced was greater, and we thus get a straight streak on the plate connecting the zero point with the parabola corresponding to the particular atom concerned. Strong evidence in favour of this explanation of the "secondary" lines in question was afforded by the fact that if the fields were very short, but correspondingly more intense, the straight lines disappeared. The lecturer had used in an experiment of this kind fields less than a millimetre in length. In that case, the positive particle had little opportunity of losing a charge, whilst traversing either of the fields of force, and the photographs obtained showed no signs of the "secondary" lines just described.

Let us consider, the speaker proceeded, what would happen if a very short electric field were used in conjunction with a long magnetic field. Then some particles might come through the electric field uncharged, and gain a charge whilst traversing the magnetic field. In that case, the particle would suffer a vertical displacement only, and it would be seen that some of the secondary lines visible in Fig. 2 joined up with the vertical through the origin at some little distance above the zero point. All these secondarys were, in short, due to the positive rays passing through residual gas at other than an extremely low pressure.

It would be observed that the parabolas shown in Fig. 1 did not run down to the zero point, but their heads all lay in a certain vertical line some distance from the origin. This was exactly what we ought to expect from the conditions of the experiment. As already mentioned, the displacement due to the electric field was proportional to $\frac{1}{mv^2}$. That was to say, inversely to the kinetic energy of the particle. The greater the energy, the less the displacement. The maximum energy the particle could receive was due to the difference of potential between the anode and cathode, and was thus the same for all particles. Hence, the smallest displacement possible was the same for all, and we found accordingly that the parabolas all started from the same vertical line. There was, however, one interesting and important exception. The parabolas sometimes showed beaks projecting beyond their proper termination point. These beaks were due to particles having more than one charge, and the energy being correspondingly greater, they were able to get in nearer to the zero line.

THE B.S.A. TOOL WORKS AT SPARKBROOK.

THE enterprise of the Birmingham Small Arms Company has long exceeded the manufacture of the articles indicated by the title of the firm, and prominent amongst its other activities is the production of small tools, gauges, jigs and machines for special purposes. This business is carried on under the name of B.S.A. Tools, Limited, in a separate factory at Sparkbrook, Birmingham, which not only supplies the requirements of the other works of the Company, but does a large and increasing external trade in its particular specialities. Indeed, at the present time, some 80 per cent. of its output is manufactured to the order of private

customers. The magnitude of the undertaking may be gauged by the fact that the Sparkbrook works provide employment for some 1,100 people, and can produce approximately 50,000 twist drills and 15,000 milling cutters per week, in addition to an annual output of something like 50,000 jigs and fixtures. Besides these there are, of course, the numerous machines designed and built for various special purposes.

The Sparkbrook works cover a floor area of 216,000 sq. ft. and comprise four main sections, devoted respectively to jigs, fixtures and special tools; gauges of all kinds; twist drills; cutters reamers, slitting saws, &c. All shops are on the ground floor and are well lighted and warmed. A visitor is at once struck by the scrupulous cleanliness observed throughout the works. The floors are maintained in perfect order, and there is not only a total absence of accumulated litter and rubbish, but even the current by-products of an actively working factory appear to be disposed of as fast as they are made. It is unquestionable that insistence upon cleanliness and order benefits both the health of the workers and the quality of the work turned out. Other features common to all departments of the factory are the general practice of piecework and the systematic methods of inspection between operations. Payment by piecework is in force wherever it can be applied, even the tool room workers and the jig and fixture makers being very largely on a piecework basis. That piecework should be found possible not merely throughout a factory where extreme accuracy of every operation is essential, but in departments where this accuracy depends more upon the craftsman than on the machine, is a practical answer to those who hold that payment by results is fatal to the best workmanship. There can be no doubt that the policy of viewing between operations, as carried out on all the repetition manufacturing processes, has much to do with the success of the piecework system. Each operation is done "to stock," partly finished articles being returned to the stores, viewed, and re-issued again as required for the next operation. Hence there is a continuous and definite check both on the quality and quantity of work coming off each machine.

The twist-drills made at Sparkbrook range in size from 0·135 in. diam. to 3 in. diam., although somewhat larger sizes are occasionally made. High speed steel is exclusively used in their manufacture. The same statement also applies to the milling cutters made by B.S.A. Tools, Limited. The nature of the operations in the manufacture of a twist drill naturally varies to a certain extent with the type and size of the particular drill under consideration, but in general the processes comprise cutting off the bar to length, turning body and shank, milling tang, milling grooves, stamping name and size, relieving, hardening, sandblasting and grinding lands and point. Whenever possible, the turning of the body and shank and the cutting off to length are done as one operation on automatic machines, while in the smaller sizes of drills turning can be dispensed with entirely. The most interesting operations are fluting, relieving and hardening. The flutes are cut one at a time on a specially designed milling machine, the blank being fed forward by means of a cylindrical former around the circumference of which is cut a spiral of increasing pitch, corresponding to the flute angle required on the drill. A fixed pin, engaging with the spiral in the former, causes the rotation of the latter, and consequently of the drill, as it is fed under the cutter. Each flute is finished complete with one traverse of the blank. As regards relieving the lands of the drill, this is accomplished either by grinding or milling, according to size. In the case of the smaller drills, the relieving machine is similar to a horizontal plain grinding machine, the drill passing through a kind of steady to support it under the action of the wheel. Inside the steady is a small projecting point of hardened steel which engages with the lip of the drill and causes the latter to rotate as it is traversed to and fro under the wheel. The path of the grinding wheel on the land is therefore always parallel to the varying spiral of the drill, so that the land is left of uniform width. To effect the relief of the larger drills a formed milling cutter is used, mounted on an axis at right angles to that of the drill. The rotation of the drill under the cutter is brought about, as in the relief grinding machines, by a fixed steel point working against one cutting edge of the drill as the latter is traversed. Each land is relieved by a single traverse.

The importance of hardening in a factory such as that at Sparkbrook need not be emphasised. The processes in the hardening shop are supervised and controlled by a metallurgical chemist who determines in his own works laboratory the best method of treating any special kind of steel or particular form of article and from the results of his experiments issues orders to the hardening shops. The heat treatment of the B.S.A. twist drills is done in an electrically heated salt-bath furnace, the temperature being controlled by regulators in the electric circuit. The actual temperature is recorded by means of a radiation pyrometer. Special jigs are employed to carry the drills during the hardening and tempering process.

After hardening, the drills are tested for straightness by girls who inspect them against the light in a suitably illuminated hood, and who rectify any which may have become distorted in hardening. The number of drills which need rectification is, however, almost insignificant. The cleaning of the hardened drills is done by sandblasting except in the case of jobbers drills and very small sizes, when the colour from the hardening is removed by scratch brushing. For testing the quality of the finished product there is a specially constructed type of drilling machine, by means of which the performances of drills can be determined at a great variety of speeds and feeds. The metal to be drilled is clamped down to a table mounted on ball bearings but prevented from rotation by means of a torque-arm connected to a hydraulic cylinder. A pipe from this cylinder transmits the hydraulic pressure to a recording apparatus on which the torque is recorded in foot-pounds. The drilling table is mounted on the ram of another hydraulic cylinder by means of which the pressure on the drill is transmitted to other recording apparatus. On the occasion of our visit a 1-inch drill was tested to destruction, being set to make a hole through a mild steel slab 3 in. thick at the rate of 18 in. per minute. The drill was run at 305 r.p.m. with a feed of ·06 in. per revolution. The torque was not measured, but the end pressure rose to between three and four tons.

As regards the manufacture of reamers and milling cutters of all types and sizes, there is little that need be said as the operations and processes are generally well-known and simple. The quantities turned out at Sparkbrook, however, are very large, and the varieties almost infinite. Press tools also form a considerable item in the company's manufacture. The gauge making department, like the cutter department, need not be referred to at length because though well equipped for its particular specialities, it does not embody operations or processes with which engineers are not generally familiar. The gauge test room contains the usual microscope measuring machines and also two projection lanterns, by which a clear cut shadow of a gauge of any kind can be thrown on a screen with a magnification of 50 diameters. This shows up in a very striking manner the minutest inaccuracy in the form of a screw-thread, a radius or other element of a gauge, particularly when the shadow is superimposed upon an enlarged drawing of the detail in question.

What is, however, one of the most important sections of the B.S.A. Tool Works, is one which we have as yet hardly referred to, namely, the jig, fixture and special tool department. The company make a speciality of undertaking the design and manufacture of jigs and fixtures for any repetition machining operations, or will produce such articles to customers' own designs. They undertake, indeed, the complete tooling up of a factory for any particular product with a guarantee of output if operated according to their recommendations. If specially designed, machines would be more suitable than standard machine tools, the B.S.A. will design and build such machines, thus relieving ordinary manufacturing engineering works of the experimentation and trouble which they would incur in undertaking work such as the design of jigs and machine tools, which would in general be quite outside the range of their experience. We hope at an early date to illustrate and describe some of the equipment which the B.S.A. have supplied to outside firms for the mass production of standardised articles.

We should not close this short notice of the Sparkbrook factory without reference to the welfare work of the B.S.A. Company. The works contain excellent canteens for the workmen and the staff, and a well equipped ambulance room with a qualified nurse always in attendance. The company also retain the services of a doctor, who visits the works on several days every week, while a dental surgeon is in constant attendance.

Boys over the age of 14 are apprenticed to three trades, namely, those of tool maker, millwright and electrician. Every applicant for apprenticeship has to produce a satisfactory certificate from his schoolmaster, and to agree to attend classes in subjects approved by the company. Further than this he is expected to attend the weekly gymnasium exercises and Swedish drill, unless he is certified as medically unfit. Lads are paid on a scale based upon age, a boy of 14 starting at 10s. per week and rising by half-yearly increments to 27s. per week when he attains the age of 20½ years. At 21 years of age the rate is 31s. per week, and after six months at this rate the youth is granted the full wage of a journeyman. The rates mentioned above are exclusive of the Ministry of Munitions awards, which amount to an additional 10s. 9d. per week to lads under 18 years of age, and to 21s. 6d. per week to older boys. Furthermore, special merits and diligence are rewarded both by anticipating the next half-yearly advance and by the provision by the company of extra opportunities for advancement.

The subjects of instruction include practical mathematics, applied mechanics, applied science, machine construction and drawing, English literature, writing and composition, history and citizenship, with incidental geography. Elementary metallurgy and the properties of materials are also taught. The classes are held on two afternoons per week in the company's time, the boys attending them, thus suffering no loss of pay. The physical training classes are supervised by qualified instructors, and are held every evening after works' hours. A special changing room and set of baths is reserved for the use of the boys. Cricket and other games are also encouraged on the B.S.A. recreation grounds, and boys are coached for the annual sports. Classes and teams compete for a challenge shield presented by the Lucas-Tooth Boys Training Fund, and individual prizes are also awarded on merit.

NOTES.

SOLID LUBRICANTS.

A VALUABLE note on solid lubricants* has just been published by the Department of Scientific and Industrial Research embodying information as to these bodies collected by the Committee on Lubricants and Lubrication. Unfortunately no one has so far succeeded in devising any satisfactory explanation of the lubricating properties of any solid save ice. It is merely known that graphite, steatite, and mica, have lubricating properties, but as to the mechanism involved we are, for the present, almost wholly at fault. The present memorandum, accordingly, is to be considered merely as a summary of existing literature on the subject, and such explanation of the action of solid lubricants as is attempted in the pamphlet amounts to but little more than the statement that solid lubricants do lubricate. Of course it is easy to see that the mere levelling up of the surfaces by the solid lubricant must be beneficial, as it tends to reduce local intensities of pressure. In general it may be said that the function of a lubricant is to take the abrasion which would otherwise be suffered by the metallic surfaces of the bearing. In the case of a solid lubricant, however, it is difficult to conceive of any mechanism by which the abraded lubricant can be restored. Ice constitutes the only solid lubri-

* Memorandum on Solid Lubricants. H.M. Stationery Office. [Price 6d.]

cent. of which the lubricating action has been explained. This is known to be due to the fact that it melts under pressure and the lubrication is thus really due to the film of liquid formed. It is just possible that with other solid lubricants the real lubricant is also a fluid and that function of the so-called solid lubricant is merely to level up the opposing surfaces to such an extent that a very small quantity of even a non-viscous fluid is capable of carrying the load.

British Blast-Furnace Plants.

"The Construction and Equipment of British Blast-Furnace Plants" formed the title of a paper read on February 28, by Mr. W. H. Buckley, M.Mech.E., before the Manchester Association of Engineers. He dealt with the subject "solely from the engineer's standpoint" and gave data on the construction of the furnace, on the blast heating stoves, dust catchers, charging arrangements, blowing plant, &c. He stated one point in connection with large steam-power units for blast furnaces, which, he added, designers and manufacturers do not fully realise, to the effect that it is sometimes most difficult to keep a definite head of steam at the boilers without an abnormal consumption of coal to assist the blast-furnace gas, this being particularly noticeable in the case of hematite plants working with dirty gas. "The primary function of a blast furnace is to make iron with a coke consumption as low as possible, and not to produce gas of a very high thermal value for boiler firing." In making this statement, the author seems to us, in view of his opening remark, to be treading on what we may be allowed to term rather dangerous metallurgical ground; the statement in question is a somewhat disquieting one, and will lead to the viewing with suspicion of all figures relating to the utilisation of blast-furnace gas when the coke consumption per ton of pig-iron made in the blast furnace is not quoted also. We are glad to find that in the opinion of the author, the last five years have seen very rapid strides in improving the general reliability of large gas engines, some of the engines put down during the war leaving little to be desired as regards regular and efficient running, these remarks applying to both the slow horizontals and the quick-revolution, multi-cylinder vertical engines. In view of the lead which was taken during the years immediately preceding the war in the development on the Continent of gas engines of high power, driven by blast furnace gases, this information is very satisfactory and of special interest.

Lighting Conditions in Mines.

The subject of the occurrence of nystagmus among miners was considered in a paper read by Dr. T. Lister Llewellyn before the Illuminating Engineering Society on February 24. In this paper Dr. Llewellyn condemns the miner's oil lamp as extremely inefficient. Not only is the lighting at the working face bad, but such as it is it falls off badly towards the end of the shift, while figures show that such poor illumination has an extremely serious effect on the eyesight of the miners. Oil lamps, for instance, tested showed a power of 0·50 Heffner units at the beginning of the shift, deteriorating to 0·28 at the end, compared with electric lamps showing 1·75 units to 2 units at the start, and 1·5 units to 1·75 units at the end. Acetylene lamps showed no deterioration. The effect of this on eyesight is reflected in the following statistics. With oil lamps the number of grave cases of nystagmus per 10,000 was 35, and of serious cases 57. The number of cases as a per cent. of the workers on day shift was 31. This percentage was reduced in the case of electric lamps to 15·4, with which the grave cases were only 8 per 10,000. Evidence shows that the introduction of the electric lamp has enabled scores of miners to continue at work underground. In two similar pits, after electric lamps were introduced into one of them the cases of nystagmus have been greatly reduced in the pit which had adopted electric lamps of 0·62 c.p., compared with oil lamps of 0·25 c.p. These lamps gave respectively 0·023 ft.-candles and 0·015 ft.-candles at the face. The men with electric lamps turned out 5 per cent. more than those with oil, while the shifts lost from accident were 1 in 54 with the electric lamps against 1 in 23 for the oil lamps. The cost of an oil lamp is put at 3½*d.* per week, while the electric lamp is said to cost ½*d.* to 1*d.* more, though figures are given claiming it to be actually cheaper at some collieries. The electric lamp is, of course, more expensive as regards first cost. In a contribution to the discussion Mr. Elworthy pointed out that it was the light reflected from the coal face which affected the miner. To give relief it had been suggested to colourwash the roof, &c., and where this had been experimentally attempted considerable relief had been experienced.

A New Competition for Naval Power?

Are we to have a new competition for naval power? The question arises owing to the cablegrams from America indicating that the Naval Board have made a report which is conceived in a competitive spirit, the aim, it is said, being to give the United States "the largest navy in the world." This seems to be borne out by the programme proposed, although it is premature to make any serious comment, as the matter is still to be considered by the Naval Committee of the House of Representatives. The attitude of the United States in connection with the Peace Treaties and the League of Nations has a direct bearing, because they cannot refuse to accept responsibility as a "world Power" and yet aim at naval dominance. Moreover, there is room for reflection on the part even of the United States as to the lessons of tactics during the war and their influence on the future design of ships. This is a question on which there is a distinct cleavage of opinion, and demands very careful consideration. But the Navy Board, which is presided over by Rear-Admiral Badger, is said to argue that battleships and battle-cruisers are "destined to remain the backbone of the Navy, with a tendency in building towards constantly greater size." Their programme aims at "outclassing" the greatest of our ships, the Hood, which has a displacement of 41,200 tons, the length overall being 860 ft., the beam 104 ft., and the mean load draught 28 ft. 6 in. The geared turbines are of 144,000 shaft horse-power, and the speed is to be 31 knots. The armament includes eight 15-in. guns, twelve 5·5-in. guns and four 4-in. anti-aircraft guns. The total estimated cost, which is an item in design that cannot be ignored, is 5,500,000*l.* sterling. The Hood is a battle-cruiser. The Navy Board proposed two new battleships, each of 44,000 tons displacement, with 16-in. guns, and one battle cruiser, which is to have a displacement of 32,500 tons, also to be armed with 16-in. guns. In addition, there are to be ten scout cruisers of 10,000 tons, with 8-in. guns, four destroyers, six submarines, two aeroplane carriers, one submarine tender and one destroyer tender, with other smaller craft. The cablegram announcing the fact makes the significant remark that the Navy Board give no estimate of the cost of the vessels proposed or of the time required for construction. It will be seen, however, that, on the basis of the cost of the Hood, the expenditure on this addition to the United States Navy will be greater than that proposed in the Navy Estimates of any one year by any Government in peace times.

The Protection given by the Trade Disputes Act.

The Electrical Trades Union's case, *Hodges v. Webb*, in which judgment was given recently by Mr. Justice Peterson, is an interesting example of the operation of the Trade Disputes Act. The plaintiff was an electrician foreman and a member of the National Association of Supervising Electricians, and in October last was engaged at Watford in the employment of Messrs. Tyler and Freeman, with twelve men under him. The plaintiff complained that the defendant, who was a secretary of the Electrical Trades Union, went to Watford and called the men out on strike because the plaintiff was not a member of the Electrical Trades Union, and that in consequence the plaintiff lost his job. He therefore claimed that the defendant should be restrained from interfering with his employment and his right to dispose of his labour as he willed. Mr. Justice Peterson, in a written judgment, stated that the N.A.S.E. although registered as a trade union, had failed to obtain recognition by the Trades Union Congress, and that the E.T.U. objected to its members working with members of the N.A.S.E., and considered that the members of the N.A.S.E. were on the same footing as non-unionists. In consequence of certain complaints the defendant, acting with the authority of the London District Executive of the E.T.U., went to Watford and called the men out because the plaintiff refused to join the E.T.U. The Trade Disputes Act provides that an act done by a person in contemplation or furtherance of a trade dispute shall not be actionable on the ground *only* that it is an interference with the trade, business or employment of some other person, or with the right of some other person to dispose of his labour as he wills; and the question arose whether the defendant was acting in furtherance of a trade dispute. His lordship held, on the facts, that he was and that the action failed. His lordship held also that it was not proved that the defendant had used any threat to the plaintiff's employers which was a sufficient basis for the action. The case may be contrasted with the leading case of *Conway v. Wade* in 1909. In that case a delegate of a trade union, in order to compel the plaintiff to pay a fine due to the trade union, or to punish him for not having paid it, went to the foreman of the plaintiff's employer and procured the plaintiff's dismissal by threats that unless this were done the union men in the service of the plaintiff's employer would leave off work. It appeared that the fine had been imposed eight years before the events in question, and had never been enforced; and the jury found that a trade dispute did not exist and was not contemplated by the men. The House of Lords held that as the defendant was not protected by the Trade Disputes Act he was liable in damages to the plaintiff. The main difference between the two cases appears to be that in *Conway v. Wade* the defendant had not the protection of the Act because there was no trade dispute in existence, while in *Hodges v. Webb* the defendant was protected because he was acting in furtherance of a trade dispute.

INDUSTRIAL NOTES.

The annual report for 1919 of the Liverpool Steam Ship Owners' Association opens with a number of examples pointing to the evil of State control. It says that throughout the year just closed all the principal ports have been congested, the time occupied in the turn-round of the ships has been nearly double that under pre-war conditions. As the number of ships available has been added to, congestion and delays have steadily increased, and thereby the yearly carrying power of the individual ship has decreased until its efficiency has been reduced below pre-war standards by at least 30 per cent. State control over many of the more essential imports has caused not only extraordinary fluctuations in the arrival of the imports but also the holding of abnormal stocks in the ports. State control has also restricted the holding of stocks in private hands owing to uncertainty as to the action of the State in regard to both future supplies and price. The uncertainty as to the future ownership of the railways and the elimination of competition between the companies has gone far to paralyse all enterprise in management. The withdrawal of the railway canvassers was described as prudent economy, but it was a manifestation of the spirit of State as distinguished from commercial control. Apart, however, from State control there are other factors which have made it impossible to pass through the ports of the United Kingdom more than 58 per cent. of the traffic with which they dealt under pre-war conditions. The principal of these is the shortened hours of labour. If the hours of labour in the ports and throughout the transport services are reduced by 20 per cent., the volume of traffic dealt with must of necessity be very substantially diminished unless better work is done in the shorter hours or more labour is employed. If the men cannot work harder in the shorter hours then better results may be obtained by employing more machinery; but the introduction of further mechanical appliances must take time. If more labour is to be employed then it must involve the introduction of extra shifts or the utilisation of more plant. In the ports where so much of the transport must be done in the open there are difficulties in the introduction of extra shifts. If the rates for day and night work are the same the men for the night shifts will not be forthcoming; whilst if the rates for the night shifts are made substantially higher the men for the day shifts may not be forthcoming. Even if the second shifts be provided on the quays little, if anything, will be gained unless all the railway, road, canal and other distributing

agencies and the receivers of the cargoes at the warehouses and in the works and factories also work night shifts. And if some cargoes are handled by day and others at night at a heavier cost, difficulties must arise between the receivers when they come to sell in competition with one another. To a certain extent the existing difficulties could be met by limiting strictly to transport the uses to which the facilities of the ports and railways are put. Double handling and warehousing are costly. The report gives also a large amount of general information on foreign competition, freights, Board of Trade returns, trade in different goods, &c., all of which will repay careful reading.

The Court of Inquiry set up by the Ministry of Labour to inquire into the application made by the National Transport Workers' Federation, referred to on page 226 *ante*, has been continuing its sittings. At the sitting of February 25, Mr. H. T. Bubbear, assistant traffic manager of the Bristol and Avonmouth Docks, stated that workmen were constantly breaking their agreement by going on strike while their claims were under investigation. The men, he said, made exorbitant demands for working overtime where vessels where partially discharged of cargo. In consequence of the refusal of these demands vessels were frequently delayed for a day or more. In some cases these exorbitant demands had to be met. There were cases where men were each paid 22*s.* 8*d.* instead of 2*s.* 8*d.* for one hour and 15 minutes overtime. As much as £2 per man had been demanded in addition to the wage allowed by the scale. It also frequently happened that the men would slow down in order that the remainder of the cargo should fall under the overtime category or go over for another half-day. The witness put in a tabulated statement which in one instance showed that while adopting this slowing up method men had been paid half a day's pay for ten minutes' work. At last Tuesday's sitting, it was stated that at Glasgow the rate of discharge of ore had decreased two-thirds. With reference to coasting vessels, the average cost per ton for handling cargo had risen nearly 300 per cent., owing, among other causes, to the slower working of the men. The average earnings of dock workers at Plymouth had risen from 32*s.* per week in 1914 to 7*l.* or 8*l.*

Speaking in Parliament on February 25 the Minister of Labour, Sir R. Horne, said his attention had been drawn to the statements made by a large firm of builders to the effect that, owing to the action of certain trade unions, there had been refusal to erect houses which had been constructed in the firm's works under a system whereby the men received a bonus on output (see page 292 *ante*). He was in communication with the firm with a view to obtaining particulars, so that the matter might be further examined. For some time the Government had had under consideration as part of the general question of the urgent need for increasing production, especially in connection with the erection of houses, the question of the advantage to the community of arrangements whereby workpeople were placed on systems of payment by results, and it was proposed to set up a Committee to inquire into and report on the whole matter.

In this connection we may add that the Amalgamated Society of Engineers held a meeting last week in Birmingham to consider the suggestion of the employers in regard to payment by results. The meeting was against the scheme, stating that the employers would note the speed of the cleverest worker and demand that the others should work at that same speed or submit to lower time rates. We dealt with this subject in several of our former issues. It was in the middle of last year that the question of instituting a 44-hour week came up for negotiation between the men and the employers, when the latter put forward a system for payment by results, a system which has been discussed periodically since. We understand that the members of the Amalgamated Society of Engineers are to ballot upon the question as to whether they are in favour of the introduction of such a system or not.

In his presidential address, delivered before the Chamber of Shipping of the United Kingdom, in London, on February 25, Mr. W. J. Noble, partner in the firm of Cairns, Noble & Co., Newcastle, and a director of the Sunderland Shipping Company, said:—"... The time had now arrived for a complete restoration of commercial and civil liberty. Government control of trade and industry had been a huge failure. Witness the present chaos in the coal trade, the muddle of the railways, the hopeless tangle of the whole transport system, the anomalies of shipping 'direction,' the complications of food control. Government control was always extravagant and wasteful. It destroyed all initiative, it stereotyped mediocrity. It was self-satisfied. It scorned advice. The idea of co-ordination was foreign to its nature. The cost was infinitely more than the owner's margin of profit and the cost of management combined. What ought to go to increase of wages was spent on whole armies of officials, whose main duties were to work the card index system and to prepare statistics to enable ill-informed Ministers to answer silly questions in the House of Commons. It was a very illuminating fact that those trades and industries which had been wholly released from control were already on a fair way towards recovery, while those which still remained in the grip of the State were going from bad to worse. Even the shipping industry, under partial decontrol, had been able, proportionately, to resume its old steamer services, to re-establish its trade connections, to place orders for new tonnage and equip itself for peace trade with surprising enterprise and energy. Was it not reasonable, therefore, to conclude that the sooner all war-time control was removed from British trade and industry the quicker would the country get into its normal stride and return to its old prosperity? . . . In regard to Labour, Mr. Noble stated that the present labour unrest was not in itself an unhealthy sign. He thought he saw in it the first fruits of the education of the great masses of the people—a striving after a higher order of life—an endeavour to raise the intellectual level of the workers on to a higher plane—a seeking for a greater degree of comfort and a better standard of living. Properly directed it should lead to an industrial condition of greater stability than we had hitherto dared to look for, provided it was accompanied by a full recognition of the fact that these things could only be permanently secured by intensive production. This, in turn, could only be secured by a still higher standard of education for the people and by the free and unfettered use of all mechanical appliances and the application of the best scientific knowledge that was available.

Last Monday Dr. Addison introduced in Parliament a National Health Insurance Bill, in which it is proposed to increase from 10*s.* to 15*s.* a week the sickness benefit paid to men, and from 7*s.* 6*d.* to 12*s.* that paid to women. Maternity benefits, now a lump sum of 30*s.* on confinement, would be increased to 40*s.* Disablement benefit, now 5*s.* a week after 26 weeks' sickness benefit has been received, would be raised to 7*s.* 6*d.* a week. The sanatorium benefit would be taken out of the National Health Insurance Acts. At present sanatorium benefit is administered by the local insurance committee, and consists of institutional or domiciliary treatment for insured persons suffering from tuberculosis; in future the Government wish to deal with tuberculosis as a whole. Higher rates of contribution would be levied to provide funds for the payment of the increased benefits.

Mr. J. H. Thomas, M.P., addressed a mass meeting of railwaymen at Southend last Sunday, and dealing with the subject of the nationalisation of mines, said that within a few weeks they would be called upon to express an opinion on one of the most important and most vital questions of the day, the system of private ownership of the mines. He believed that this system stood condemned, but he impressed upon the meeting the urgent importance of showing common sense by realising that it would be better, easier and simpler to obtain the nationalisation of mines in the best and most constitutional way. In regard to wages and high prices, he declared the vicious circle in which they were living must come to a close. In the end it would prove disastrous both to the working classes and to the country as a whole to continue this system of getting more advances in wages for one section and artificially throwing up the cost of living for all. One of the most dangerous factors, both to the future of the country and to the prosperity of the working classes themselves, was the absolute and complete failure on the part of Government to stop this increase in the cost of living. It was for Government in the interests of the country to recognise to the full the danger that this was likely to lead to. What advantage was it, he asked, to have in this system a man receiving 5*s.* more wages if the following week they knew perfectly well that prices were going up 6*s.* more than before. The cruel and hard part of the situation was that there were millions of people in this country who had no trade unions behind them to take up their case and demand sufficient to live on. Those were people for whom they should have some regard and on whose behalf they were compelled to go to Government and say they were not content with allowing this situation to continue. Matters could not run on in the way they were going to-day, and in order to counteract the effect of the reduced value of the pound in America much more must be produced than now.

At the invitation of the Minister of Labour a conference was held last Monday in London with representatives of the Parliamentary Committee of the Trades Union Congress, and of organisations of ex-soldiers and sailors, to consider the best means of facilitating the re-employment of ex-service men. At the close of the conference the following official statement was made:—"At the invitation of the Minister of Labour a conference was held to-day at Montagu House, under his chairmanship, between representatives of the Parliamentary Committee of the Trades Union Congress and of the National Federation of Discharged and Demobilised Soldiers, the Comrades of the Great War, and the National Association of Sailors and Soldiers, to consider the best means of facilitating the re-employment of ex-Service men. After a full discussion it was unanimously agreed that the problem was one which required for its solution the full co-operation of the Government, employers, trade unions and ex-Service men. It was accordingly agreed in principle to recommend the early formation of a National Committee on which these interests should be represented and which should have full powers to examine the matter and make recommendations."

Captain Bagley, M.P., who had asked the Minister of Labour for the average rise in wages in the principal Allied countries since the beginning of the war, has received answer to the following effect:—"Neither in this country nor in any of the countries allied or associated with us in the late war are the most competent statistical authorities as yet in a position to state with anything approaching certainty what has been the extent of the rise in the level of money wages since 1914. Conclusions based on comparisons between the figures given below for different countries can, therefore, only be drawn with the utmost reserve:—*United Kingdom.*—The percentage increase in rates of wages since 1914 has varied widely in different industries. For all industries combined the average increase is estimated at about 120 to 130 per cent. In most industries also the working hours have been reduced. *France.*—The official data for estimating the general rise in money wages above the pre-war level do not extend beyond the end of 1917, at which time they suggested a figure in the neighbourhood of 90 per cent. There is evidence that the upward movement has not been arrested; but the data available for measuring its extent are altogether inadequate. *United States.*—Official and competent unofficial estimates would indicate an approximate rise of 90 per cent. for men and 70 per cent. for women. *Italy.*—The only figures available for showing the general trend of money wages since 1914 are supplied by the U.S. Commercial Attaché at Rome, and point to a rise of about 180 per cent."

We are informed that agreement has now been arrived at as between the London members of the National Federated Electrical Association and the London District Committee of the Electrical Trades Union as to rates and working conditions. The agreement, which was signed by both parties on February 27, makes the rate now payable to a fully qualified electrician 2*s.* 3*d.* per hour, and assistants over 21, 1*s.* 9*d.* per hour, the men to get from home to job and from job to their homes in their own time if the job is within the agreed upon area, namely, 12 miles from Charing Cross and within 12 miles of the employers' office. A Joint Committee has been set up to adjudicate on any disputes that might arise as between the parties, also as to the interpretation of the rules, and to consider, for submission to the parties, any further rules which might be suggested. The signing of this agreement will, it is hoped, do away with the friction that has existed for many years between the members of the E.T.U. and their contractor-employers.

ELECTRICAL PLANT FOR SOUTH AFRICA.—With reference to the announcement on page 298 *ante*, respecting a call for tenders for the supply of electrical plant to the Oudtshoorn Municipality, H.M. Trade Commissioner at Cape Town states that the time for lodging tenders has been extended from March 24 to April 24.

ROADSIDE MOTOR FUEL SUPPLY STATION.—The Automobile Association and Motor Union state that a complete motor spirit bulk storage station on the latest plan has been installed at Aldermaston, on the Bath road. This is the first of its kind in Great Britain, and is the first of a series being erected by the Automobile Association throughout the country. These stations are being installed with a view to popularising bulk storage and to prove to the motorist and to the motor spirit retailer that the system is one which should be universally adopted, as, when the system is general, the cost of distribution and, therefore, the cost of fuel to the motorist can be very appreciably reduced. The Automobile Association add that they make no profit on any of the spirit sold, but allow th local Automobile Association agent and retailer to use the installation for selling his own spirit in the most practical manner. For the moment only benzole, the quality of which conforms with the specification approved by the Automobile Association, is stocked, but as and when other home-produced fuels—such, for instance, as power alcohol—come on the market, it is probable that they will also be supplied.

FLYING BOATS—THE FORM AND DIMENSIONS OF THEIR HULL.*

By G. S. BAKER, Member.

SUMMARY.

THE development of speed in transit in various cases and the strategic and commercial value of aeroplane carriers are considered. The relative advantages and disadvantages of flying boats and land machines so far as Great Britain is concerned are stated.

The dynamic requirements of the hull are given, and are considered in detail under the several headings of diving at low speed, and seaworthiness (§6), ability to change trim at high speeds (§7).

Detail consideration is given to the subject of main dimensions of hull in general, loading up a hull of varying beam (on propulsion and transverse stability) (§§10, 11), number and position of steps, and longitudinal contour of ends, and requirements of wing floats.

A comparison is made between results obtained in full-scale tests, and of similar results deduced from tank results.

A short account of work done in connection with stresses on the hull of a float, when moving in waves on the water, and formula for calculating the resulting bending moments, and maximum impact blows are given, together with approximate figures for maximum local stresses obtained from tests on a machine in smooth water.

The major part of the paper is based on research work carried out for the Advisory Committee on Aeronautics by the author and Mr. E. M. Keary. Mr. G. H. Bottomley was in charge of the impact experiments with models mentioned in §19. The author wishes to record his obligations to his staff, and these two in particular, for their devotion and skill in carrying out the work. His thanks are also due to Wing Commander Busteed, R.A.F., without whose support the full-scale work, which the Tank has carried out at the Isle of Grain Experiment Station, would not have been possible.

INTRODUCTORY.

§1. The subject of the paper is one which in its infancy has been considered one of aeronautics only, but the passing of time is bringing it more and more in the realm of shipbuilding, and the knowledge and art of the shipbuilder are becoming a necessary adjunct to progress in flying at sea, and will become even more so as the flying machine increases in size.

Before passing to the design of the flying boat hull, it may serve a useful purpose if some reference is made to the development of speed both on the water and in the air, for progress in either of these may, and probably will, have a large effect upon commercial activity in the other. There is a fascination in speed which has been felt by mankind in all ages, and its attainment has always been, and will continue to be, the predominant element in sport. Any device or invention which has demonstrated its reliability in the sporting world as a speed producer is almost certain to find a place in the commercial world. For in all transit problems accepting reliability, the only test of any means of transport is: "Can more profit be secured in this way than in some other way?" Apart from commercialism, however, speed is of such strategetic and tactical value, that, in recent years, it has been the leading consideration in many designs and types of ship. In the last fifteen years the speed of all battleships has increased 25 per cent. to 40 per cent.; the speed of submarines has doubled and destroyers can now do 40 knots. With increase in speed on the water, types have been developed which evade the most serious cause of resistance at high speed by so utilising the pressure in the water that the vessel is lifted to the surface and skims on the top. The racing motor boat and the "coastal motor boat" are of this type, and this will be the next step in destroyer design. When the resistance approximates to one-eighth the displacement it is a debatable question whether it is not easier to travel by air than by water. This is about the resistance of an air machine, and provided the necessary power can be installed and utilised in the machine, the air has several advantages over the water.

§2. A flying boat is essentially a flying machine for travelling over the water from port to port. It differs from the seaplane in having only one float which acts as a fuselage and to which are attached the main and tail air-wings. Compared with a land machine it has several advantages and disadvantages. Of the latter the chief are:—

(*a*) That it can only rise and settle on water and cannot be used for inland traffic unless there is a fair expanse of inland water. Several water machines have been built for this purpose, the Sopwith Bat boat taking the Mortimer Singer prize in June, 1913, for getting off from the sea and coming down on land, and starting from land and alighting on the sea. There is little doubt that in small machines at least, this difficulty could be overcome, if there was a real demand for an amphibious machine.

(*b*) Unless carefully designed it is a little slower in speed and cannot be put through the same stunt performances as a land machine. However, one of the most severe stunt tests is to loop the loop, and a flying boat designed by the Supermarine Aviat'on Company was looped in 1918, the pilot being Captain Goodwin.

(*c*) In all probability a flying boat aerodrome would require a slightly larger staff, unless the boats are sufficiently seaworthy to remain anchored out in moderate weather. The importance of this factor diminishes with the increase in the size of aerodrome, and most of the types mentioned in the paper have shown themselves capable of weathering severe sea conditions—in one case a prolonged gale on an open coast.

Against these have to be balanced the advantages:—

1. The very serious difficulty with heavy land machines—the pressure on the chassis wheels—is entirely absent in flying boats.

2. It is not restricted to certain aerodromes for settling, but can settle safely at any port required.

3. The main use of aeroplane carriers in the immediate future will be on such trade routes as are not served by fast railways, and, as far as Great Britain is concerned, the trade routes to Scandinavia. The ports of Germany and America are almost entirely reached by water, and any machine not capable of settling on the water would hardly come up to accepted standards of safety on these routes.

This serious disability of land machines working on water routes was brought out strongly last summer by their failure to leave Newfoundland for many weeks, and the ease with which the American flying boats left soon after their arrival. It has also been demonstrated since the armistice by the loss of land machines in the English Channel and the Mediterranean.

§3. Reliability of service is an essential for any transit service. On this matter the author is hardly in a position to make any authoritative statement. His own experience has been confined to experimental work for which fine weather was required, and he can only quote Mr. Holt Thomas, who states that it should be possible to obtain an 80 per cent. efficiency on the London–Paris route, and the figures given in "The Daily Mail Year Book," which show a 96 per cent. efficiency for the six weeks, August 25 to October 4.

In some respects the paper is incomplete, but that is a necessity in dealing with a subject on which exact data is very scarce.

FLYING BOAT HULLS.

§4. In the course of the last seven years, several types of flying boats have been designed and flown, but practically all of them are on the same general lines. Success in the hull design, however, depends on detail to a very large extent, and the purpose of the paper is to bring out the essential factors and to show the effect of variation in certain features of design, as determined by tank and full-scale work.

A flying-boat hull replaces the carriage, body and fuselage of an ordinary land machine, and the main wing surfaces, and usually the tail wing system, are attached directly to it. The lower surface of the hull is of the hydroplane type, having a step in the bottom at or about the longitudinal position of the centre of gravity of the machine. As the hull carries the tail system it is made longer and finer than is necessary for either buoyancy or planing purposes. The planing surface of the forebody is usually made of greater beam than the body of the hull to secure a large planing area and buoyancy forward, without large weight of hull.

All modern flying boats have a negative metacentric height when at rest, and require small floats to keep the wings from contact with the water. This is dealt with in §11.

§5. *Dynamic Requirements of Hull.*—When the machine is flown from rest, like all other water vessels, its first tendency is to sink to a slightly lower level and to trim forward—the trim being increased a little by the high position of the propellers. Above 12 knots or 14 knots, it trims back and ultimately planes—usually at speeds varying from 18 knots to 24 knots according to loading. After the planing speed is reached, the stern trim either remains constant or slowly diminishes and from this stage onwards until the flying speed is reached, the pilot can control the longitudinal inclination within certain limits. For good performance therefore three things are required:—

(*a*) Absence of diving or nosing under at any speed.

(*b*) Seaworthiness and absence of any tendency to leave the water before flying speed is reached, either by porpoising or bucking.

(*c*) Ability to change trim with reasonable control moment when near the flying speed, so that the machine can be held on or got off the water at any instant.

§6. *Diving at Low Speed.*—This could easily be avoided by elongating the bow; but a long bow is a serious objection in the air, as it adds unnecessary weight and tends to directional instability. Rapid changes of curvature of the planing bottom in the longitudinal direction should be avoided, the chine lifted gradually towards the fore end and the beam over chine maintained fairly full towards the bow. Under these circumstances diving will not show itself unless the hull is overloaded.

Seaworthiness and Porpoising.—At low or taxi speeds, the conditions are much the same as for motor boats, and to some extent must be met in the same way, by keeping the chine fairly high and full in plan at the fore end. The sections should be shaped to divide the water easily and beat it down, and for the latter require to have a reasonably flat surface on each side close to and beneath the chine. If the sections are made V in shape from middle line to chine, more spray is thrown up, and the steeper the V the higher the spray is thrown. Working longitudinal ribands under the bottom had little or no effect on this spray, but similar ribands along the lower edge of the chine of a model having V sections reduced the spray a little, at and above the hump speed. Above taxi speeds and when accelerating to get off, many flying boats if left to themselves will develop longitudinal oscillations, leading to the machine taking leaps off the water—a phenomenon usually called porpoising or bucking according to the type of oscillation. In some types which possess this defect it can be easily overcome by small and steady moments exerted by the elevator. The heavier the machine the more important are the stresses produced by the impact at the end of each leap, and the more objectionable does this feature become.

The longer porpoising is delayed, the greater is the damping effect of the wings, and the more air control the pilot has over the machine, while the possibility of checking any oscillation is also greater. True porpoising never develops in smooth water until the hull is planing cleanly, and, where there is ample horse-power for propulsion, it is better to keep this minimum planing speed as high as possible. Reduction of depth of step to nil at the middle line, or increase in slant of cross-sections near the step are both effective in this direction. Tank experiments have led to the development of several forms which do not porpoise at all, even on a choppy sea. These have two steps, kept as far apart as possible, the rear step being shaped to meet the water leaving the front step at a relatively small angle, the step being given a deep V for this purpose. These machines run at moderate speeds with water in contact with both steps and the hull between them. By far the major portion of the load is then taken on the fore-body, which is also responsible for nine-tenths of the water resistance. The after step is giving a little lift and serves to balance the tipping moment due to the forebody and the slight suction developed between the two steps.

The centre of gravity should be at or abaft the step. There is no critical point in this connection, but the latter gives better results, and earlier porpoising has resulted in several cases by taking the centre of gravity of the machine forward.

§7. *Change of Trim at High Speeds.*—It is desirable that a machine should be taken off the water soon after it has reached its minimum flying speed, so that the shape of the float must allow of the pilot trimming the machine back to the necessary angle without the tail hammering on the water, and this must be achieved without the use of excessive control moments.

If the hull is stable longitudinally it will have a natural running angle of its own, which is determined by the relative positions of the steps and tail until the getting-off speed is nearly reached, when the relatively greater air forces are the main factors in determining this angle (see also §13). When the front step is on the water it leaves a shallow furrow in which the rear step or tail works, so that the longitudinal line joining the two steps is at a slight positive angle; this is a rough criterion to the natural running angle of the hull. But change in shape of transverse section, particularly of the rear step, affects this to some extent, and experiments are required to determine it for any new type. When this is known the hull should be arranged on the machine so that the wing chords are at the angle for minimum flying speed when the hull is nearly at its natural running angle.

A machine in settling should always do so with stern trim. This ensures low flying speed, and first contact with the water on the second step, *i.e.*, aft the centre of gravity. Settling at small angles mean water contacts at high speed with a large area of bottom, and a possible awkward leap off the water. All modern flying boat hulls have good restoring moments if held forward even to minus one or two degrees on the hull, but if the machine settles with the fore body at negative angles of more than 3 deg. or 4 deg. (*i.e.*, the planing bottom at negative angles) the hull in some cases will not lift, but continues to enter the water or dive—leading to the breaking up of the machine.

To ensure easy contact when settling on the water all large machines are formed with V or rounded sections below the chine line. First contact is then made on the keel, or ridge of the V, at the first or second step, and with average pilotage there is no shock. In the "America" and "F" types the angle of the V at the step varies from 145 deg. to 160 deg. In later types such as the C.E. 1 the angle of the V at the keel is 130 deg., but taken from keel to chine is 147 deg. Both of these types have good reputations for settling. In recent designs of large boats the angle has dropped to 130 deg.

§8. *Main Dimensions.*—It is of great importance that these should be as small as possible consistent with good design. A large hull has three objectionable features—greater (and useless) weight to be carried, greater air resistance, and lower centre of gravity.

The length from the centre of gravity to the tip of tail is fixed by aerodynamic requirements as the tail carries the tail fin and rudder system. The length forward of the centre of gravity should be the least possible consistent with good planing and reasonable seaworthiness. This has been determined in practice by experience, experiments in the Tank being used to determine the comparative behaviour of any form when modified in this respect.

Fig. 1 has been drawn to show the effect of increase in all dimensions of hull upon the horse-power required at low speeds up to the hump with a certain load (10,000 lb.). As the larger hull will involve a greater weight, it has been assumed that the relative weight of hull varies as the total area of skin of vessel. Table I gives the dimensions, and weights so obtained. The smaller hull requires more power on the water near the hump speed, but the decrease in weight of hull is sufficient to compensate for the extra weight of engine required, and the weight is utilised for propulsion in the air instead of being mere deadweight.

§9. The maximum loading which can be carried on a hull of the P. 5 type has been determined by a series of model experiments. The lines and dimensions of this form, to carry 90,000 lb. with a minimum flying speed of 50 knots are given in Fig. 2. The horse-power to overcome the hull resistance, running angle, &c., are also given for this form in Fig. 3. Better performances have been obtained as is detailed later, with modifications

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, on Friday, February 27, 1920.

of the type, but only with sacrifice of load capacity. This is the best or optimistic load—not a design load—which can be carried in this hull, to give good results. For a displacement of 10,000 lb. and the same flying speed, with one exception all the dimensions can be halved; but the forebody length requires to be about 18 ft., *i.e.*, a little more than one-half, to give good results at low speeds.

TABLE I.—*Comparison of Effect of Size for Constant Load.*

Type 223 at 10,000 lb. displacement.
61·3 knots minimum flying speed.

Stem to main step	.. ..	0·44 of length.	
Main step to second step	.. ..	0·22 of length.	
Main step to tail	.. ..	0·56 of length.	
C.G. of machine above bottom of forestep	.. ..	3·2 ft.	
Propeller axis above bottom of forestep	.. ..	13·2 ft.	
Length of hull (overall) in feet	..	35	41 46·4
Maximum beam—			
Over body in feet	.. ..	4·28	5·0 5·65
Over chine in feet	.. ..	6·0	7·0 7·9
Maximum E.H.P.	.. ..	144·0	116·5 106·0
Speed for maximum E.H.P. in knots	.. ..	19·0	20·0 20·5
Relative weight of hull—pounds	..	425·0	580·0 750·0

When a hull is loaded to excess, it develops a tendency to wallow or nose under at speeds in the neighbourhood of 10 knots to 13 knots, and it is at these low speeds that the bad effect of loading is mostly felt. At higher speeds the wash thrown up from the chine of the fore-body increases in height with loading and may damage the propeller, if this happens to be in the line of the divergent wave. The hump speed and flying speed are both increased by loading, and the ratio of lift to resistance for any speed falls a little.

§10. *Beam.*—In the earlier types considerable attention appears to have been given to the retention of an upright position when at rest. This involved either twin floats or single floats of large beam. Experiments were therefore made in the tank in 1915 to determine the effect of beam on propulsion, and later on transverse stability. The first experiments were made on the America type. The general dimensions of the early America type are given in Table III, and the lines in Fig. 2. This type was tried with beams of 8 ft. and 6 ft. with plain V-sections to the fore-body as in Fig. 2; and with sections rounded as in the body plan. It was found that the reduction of beam produced only a slight increase n the maximum power required for propulsion.

Similar experiments were made on hulls of the same type as P. 5 (Fig. 2), tank models number 223 A, B, and 222, and more recently on other models of this type (models 389, &c.). These results are summarised in Table II. It will be seen that when the beam is narrow

TABLE II.—*Variation of Maximum Power with Hull Beam.*

Machine of 10,000 *Lb. Total Displacement.*

Models Compared.	Beam over Chine.	Percentage Increase in E.H.P. for 1 Ft. Decrease in Beam.	Hull Length Overall.	Remarks.
	ft.		ft.	
222	3·5	9·75	41·0	Two-step type.
223 B	5·25			
223 B	5·25	6·85	41·0	Two-step type.
223 A	7·0			
130 E	5·36	3·12	46·9	America type with curved sections to bottom.
130 D	7·14			
389 A (deep)	6·53	2·76	30·0	Two-step P. 5 type. Beam varied keeping constant rise of chine above keel at all sections.
389 C (deep)	9·80			
390 A	7·04	1·45	42·0	Two-step P. 5 type. Beam varied keeping slant of all sections constant.
390 C	10·56			
150 A	8·5	0·87	44·6	America type.
147 A	10·9			

Model 222 was a distinctly "dirty" model, and created a much worse water disturbance than model 223 B, with which it is compared.

for the length, a change in beam produces a fair change in maximum power required to overcome the water resistance; but when the lifting surface is sufficient to give clean running, there is very little to be gained by increase in beam—not sufficient to compensate for the extra weight involved. These maximum powers are required at a speed roughly 0·4 the minimum flying speed of the machine, being a little lower with wide beams or large planing surface. When the speed has been accelerated to about 0·7 the flying speed and above, the larger beam is usually somewhat more resistful than a narrow one. The general effect is independent of type of float and of the mode of varying the beam within the limits of tank experiments, and of the minimum flying speed.

§11. Flying boats, even though they are given quite large beams—up to a quarter their length—are unstable transversely, and without wing or wing-float support, would topple over at rest. Reduction of beam only renders this negative metacentric height a little greater, and puts a little more load on the wing floats. In an ordinary breeze the machine will cant slightly to one side. With a fair negative metacentric height it will remain canted to one side, instead of lolling from one side to the other with any small change in loading, direction of wind or sea. Before reaching high speeds this instability must disappear of itself, or the pilot must be able to eliminate it. Experiments made in the tank have shown that a hull whose breadth was only 2/17 its length, having a negative metacentric height of 2·5 ft., came upright of its own accord when the planing speed had been reached (21 knots) and was stable at higher speeds. The experiments were made on a model 8·5 ft. in length, fitted with air wing surfaces so as to obtain and measure any effect due to the proximity of the air surface to the water surface. The transverse instability was ascertained by measuring the vertical force required at the wing float position to keep the wing tip just out of water at a series of speeds. The planing surface of the hull was given convex, concave and straight V transverse sections in different experiments; but shape of section had very little effect on the general result. The presence of the wing caused a slight reduction of the instability, but it was never important, and the hull, without any wing lift, came almost upright at 21 knots of its own accord and with full load on it. These results were obtained with forms having a reasonably good planing surface, and warrant the conclusion that beam may be reduced on any hull to the lowest limit for propulsive efficiency, without fear of ill-effect on transverse stability. The general result was confirmed by an experiment carried out on an A.D. machine at Southampton. This had a negative metacentric height of 1·5 ft. at rest, but came upright—both wing floats off the water—at 25 knots to 30 knots, in a light breeze.

§12. *Number and Position of Steps.*—The main step is required to be more or less under the centre of gravity of the machine. Reasonable variations of longitudinal position can be made without serious effect on the resistance, but the change of longitudinal attitude when running may be important—a shift of step aft always reduces the running angle. An experimental machine of 4,600 lb. total weight, America type, having its only step 4 ft. aft of the centre of gravity of machine, had insufficient elevator control to trim it back for getting off, and this could only be effected by rocking and jumping it off. In some machines in which the step was placed a little before or under the centre of gravity the longitudinal stability on the water has been exceedingly good. The shape of the section at the main step has been referred to in §7 in connection with settling. Small transverse inclination of section has little effect on the propulsive efficiency, and if the V of the bottom is associated with a flat at the side near the chine, as in the P. 512 and 416 forms, Fig. 2, angles of V up to 130 deg. can be accepted. In plan the step section may be perfectly square to the middle line plane or brought forward towards the sides—it makes little difference to the general result. Air pipes were used in some original hulls for ventilating or supplying air to the step, but have been given up in favour of better shape of hull, as they were always a source of weakness. The depth of the step should increase steadily from the keel to the side of the float and just abaft the step; the hull should be rounded up to give an abrupt break in the form, at the step. This method of ventilation was adopted successfully in the Thornycroft and some other types of "planing" boats, and has been used in many flying boats.

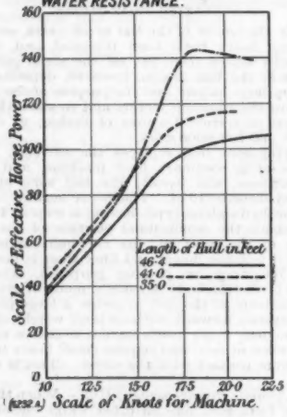
A second step, or something which behaves as, or takes the place of, a second step, is necessary in a flying boat. Without it the machine cannot be "unstuck."

TABLE III.—DIMENSIONS OF TYPICAL FLYING BOATS.

	Type of Hull. *					
	America.	F. 5.	C.E.I.	A.D.	P. 5/2.	416.
Tank model No.	147 A	382 D	272 D	Derived from 13·5	353 A	416
Total weight, in pounds	4,500	12,000	4,000*	3,460	12,000	90,000
Getting-off speed, in knots	41·0	—	43·0	50·0	49·0	50·0
Length of hull in feet—						
Stem to step	11·5	21·4	12·3	13·5	18·0	30·0
Between steps	Tail is the step	7·0	Tail is the step	7·9	13·5	32·0
Overall	30·0	45·0	28·0	30·0	45·0	84·0
Maximum beam in feet—						
Over body	4·0	5·2	3·54	4·0	5·7	11·0
Over chine	8·0	10·0	4·83	4·0	7·7	14·1
Load per square foot of fore body planing surface (in plan)	56·25	70·35	83·3	91·2	107·65	254·7
Wing chord to datum, in degrees	+3·0	+4·0	7·0	+2·0	—	—
Inclination of tangent to keel at front step	0·0	+3·5	1·9	1·0	−2·0	−2·0
Inclination of line from chine of front step to chine of second step (in degrees)	−5·0	−4·0	−4·5	—	−5·0	−5·0
Inclination of line from keel of front step to keel of second step	−6·0	−7·0	−3·5	−5·0	−7·5	—
Inclination of datum to horisontal at high speed when rear step or tail is just flicking water (degrees)	7·1	5·5 to 9·0	3·0	7·0	7·0	9·0
Centre of gravity—						
Above bottom of step, in feet	6·0	6·6	5·5	5·8	7·0	15·2
Relative to step, in feet	2·0 For'd	3·1 For'd	2·1 Aft	0·6 For'd	0·5 Aft	Over 20·5
Prop. above bottom of step, in feet	6·9	10·7	9·0	9·5	9·5	
Nominal engine brake horse-power	160	—	250	180	700	—

* Has been tested to 4,650 lb. without porpoising and without control.

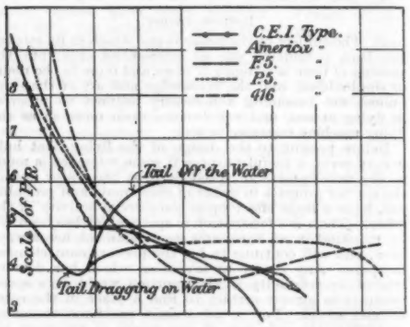
Fig. 1. EFFECT OF HULL DIMENSION ON POWER REQUIRED TO OVERCOME WATER RESISTANCE.

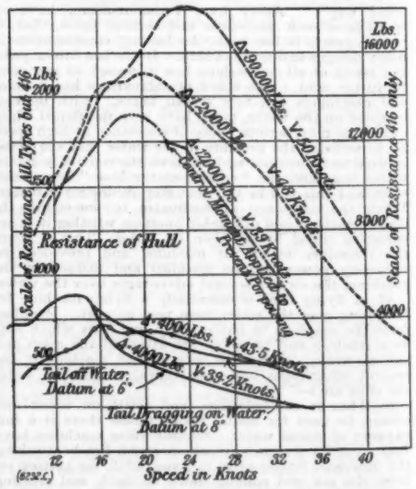


(252 A) *Scale of Knots for Machine.*

Fig. 3. RESISTANCE AND EFFICIENCY CURVES FOR VARIOUS TYPES.

Δ Is the Load Displacement.
V Is the "Getting Off" Speed. *Load on Water / Resistance* = $\frac{L}{R}$.

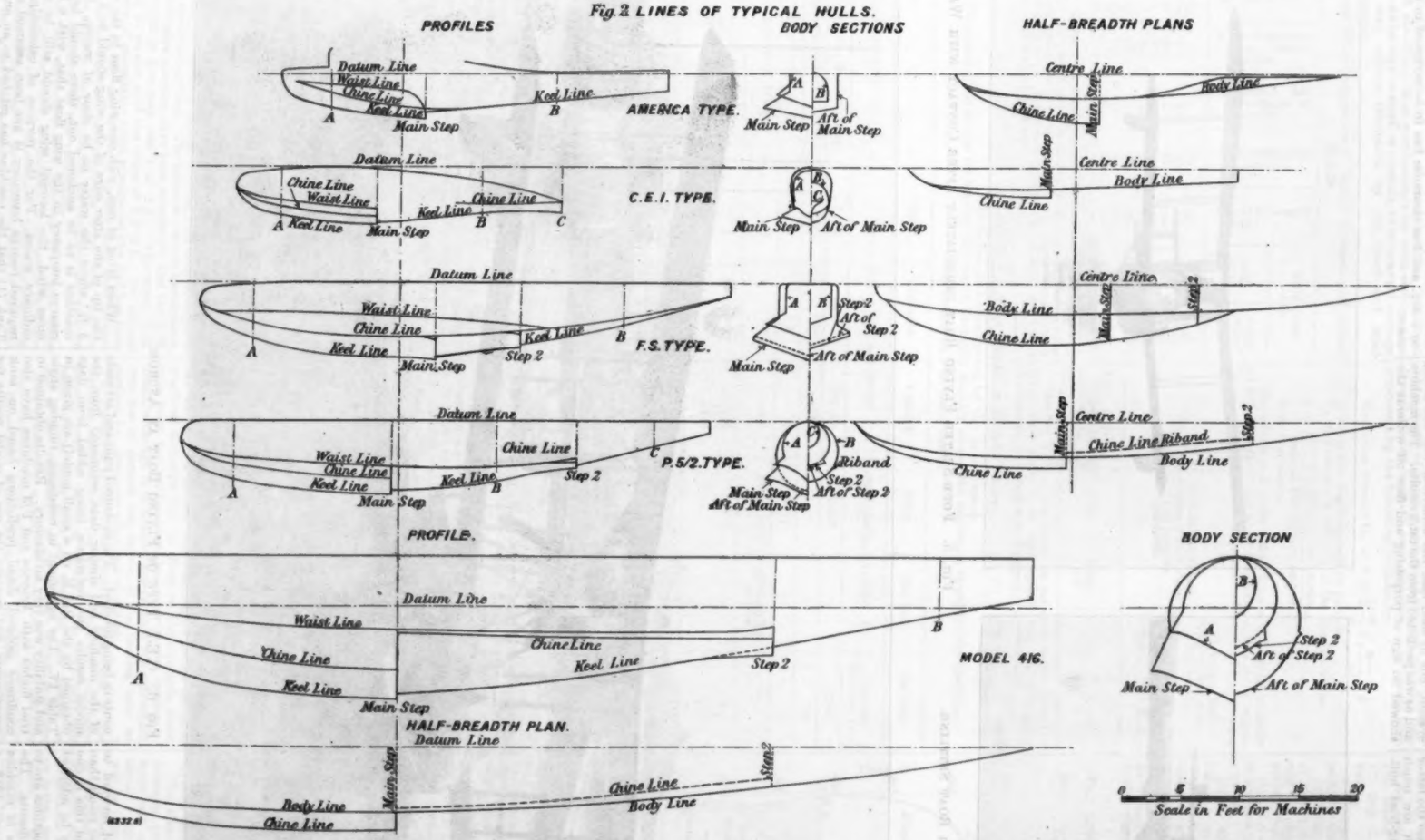




(252 C)

FLYING BOATS: THE FORM AND DIMENSIONS OF THEIR HULL.

Fig. 2. LINES OF TYPICAL HULLS.



In the original America type the flat under surface of the tail acted as a second step. When this flat was rounded off, so that it was unable to act as a step, the tail could not be unstuck from the water. A worse result was obtained with an A.D. type machine from which the second step was removed for a trial. The after sections of this hull were oval and the tail could not act as a step. The machine failed to reach even ordinary taxi speeds, and stalled to a very large angle with tail and tail plane in the water.

Tank experiments have shown that this step need not be wider than 1/2·5 the width of the main step, and that if placed some distance aft the main step, it can be given a deep V shape. This will develop sufficient moment to balance the hull, and any contact between it and the water when getting off or settling is very gentle, owing to its shape. It should be formed with a chine running practically parallel to the fore body chine at the main step, and should be continued forward almost up to the main step. The tail beyond the second step should be lifted up out of water, as this keeps the tail air system dry.

If the second step is placed close to the main step, it serves no use except at the moment of settling or getting off. With the step somewhat further aft it serves to break away the tail and keep it clean, but such forms usually show a tendency to porpoise. When the distance between the two steps is increased to at least 12 ft. with flying speeds of 40 knots to 50 knots on a hull of 37·5 ft. length, tank experiments have given fairly good propulsive results, and in some cases an absence of all longitudinal oscillation when accelerating. Although it cannot be stated as a general rule, it is believed that a long distance between steps gives better results than a small one.

§13. *Longitudinal Contour of After End.*—This is intimately connected with the longitudinal position of the second step, and the settling of the hull relative to the chord of the main wings. The wing chord is usually placed at an angle of 3 deg. to 6 deg. to the general line of the hull, called datum in Table III, page 324, so that in normal flight the hull will be heading directly into or at a very small plus angle to the wind. To get off the water at the lowest possible speed, the wing chord must be at a plus angle of, say, 10 deg. to 14 deg.—not quite the stalling angle of the machine—and the stern must be uplifted to allow of this without serious contact of the second step on the water. Angles for certain typical hulls are given in Table III, together with the ascertained angle to which the datum can be inclined with the rear step just flicking the water. The sum of this angle and the "wing chord to datum" should be either equal to or slightly more than the angle of wing chord for the getting off speed. Between the two steps the contour can be straightened out. Aft of the second step, as deep a post as possible is required to give security for the tail system, and the contour is either carried through the second step in a straight line (P/5·2), or uplifted a little towards the end (F/5).

§14. The contour of the fore end has been dealt with in general terms in §6. It has been found in recent tank experiments, that the load carried by a hull can be increased if the chine and contour are lifted at the fore end, but the resistance at the hump speed is increased by it. A form of type 416 was tried against one having exactly similar shape from the after end to just forward of the step, but with flatter chine, the tangent at the fore end being at 3 deg. less inclination than in 416. The maximum load of 416 exceeded that of the modified form by 12 per cent., its resistance per ton was a maximum of 17 per cent. greater at 24 knots, but the same at speeds above 32 knots. With plenty of power, therefore, 416 has an advantage, but with low power the flatter chine form would be necessary.

§15. Resistance curves and ratios of load to resistance for the America, C.E. 1, F. 5, P/5 types and 416 are given

in Fig. 3. These powers are for air and water resistance of hull only, the load on the hull being decreased as the speed is increased, due to the action of the air wings. The total weight and getting-off speeds are given on the resistance curve for each type. It should be noted that the ratios of load to resistance are smaller than are obtained with skimming boats, largely because the latter invariably run at angles of attack which are much smaller than could be accepted for a flying-boat hull. One of the objects in view in the design of the hull of the machine had been the avoidance of porpoising, and the tank experiments showed that this had been obtained. The machine was therefor allowed to accelerate to the flying speed, without the use of elevator controls. The experiment was repeated with different setting of the tail system, but in each case the behaviour was the same, and as was predicted from the tank results. The machine showed no sign of porpoising and flew off without the well clear of the water. The chine line at main step will then be slightly lower than the general water level, and the bottom of the wing floats should be at least 2 ft. to 3 ft. above this level for a machine of about 10,000 lb. weight and above. In small machines, this clearance might lead to undesirable inclinations; when at rest the transverse inclination should not exceed 3 deg. to 4 deg. and less clearance has to be accepted in their cases.

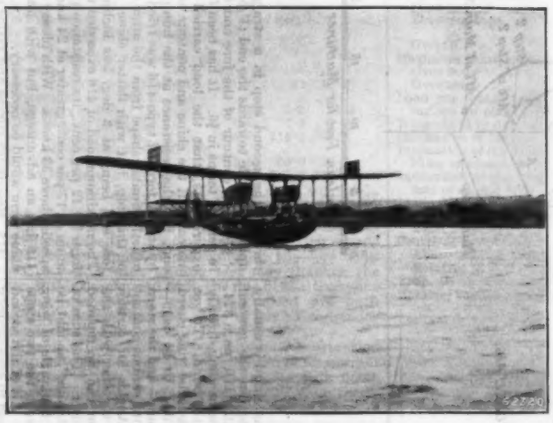


FIG. 4. P 5/2 FLYING BOAT SETTLING.

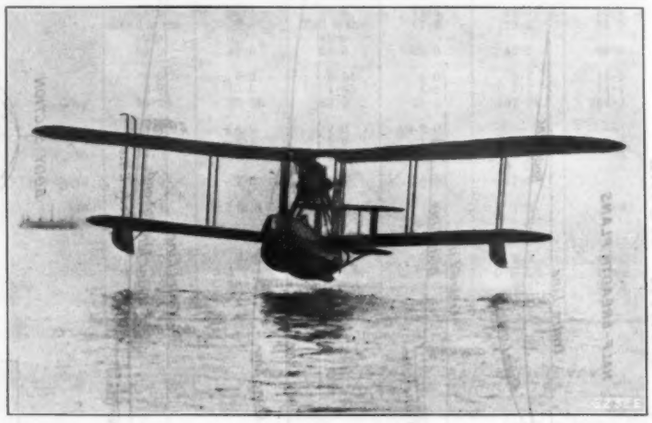


FIG. 5. FOUR-SEATER FLYING BOAT IMMEDIATELY AFTER CONTACT WITH WATER.

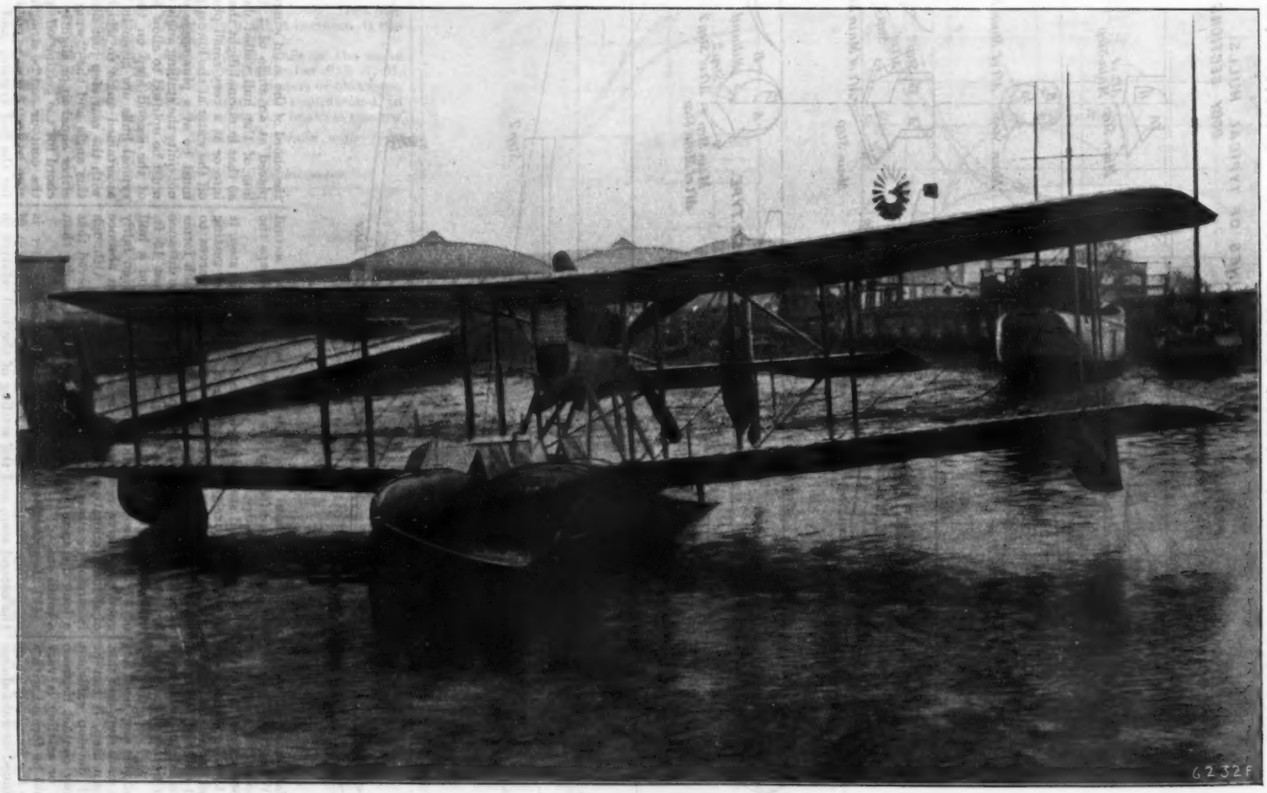


FIG. 6. C.E.I. TYPE OF FLYING BOAT AT ANCHOR.

If any flying boat is deliberately trimmed forward to slightly smaller angles at high speed, a better result than that given can sometimes be obtained, and this is one method of accelerating quickly which can be adopted by a skilful pilot.

§16. The results given in the preceding sections are to a large extent based upon model experiments. The desirability of comparing the performance of machine and model was fully recognised, and in April, 1918, a machine of C.E. 1 type was allocated for this purpose. This machine was towed early in 1918 at the mouth of the Thames, by a torpedo-boat destroyer at a series of speeds, and its resistance, attitude, &c., were measured. controls being touched. The measured pulls and attitude of the machine and similar data estimated from the model results (air resistance being added from data obtained by the R.A.E. on a small model) are given in Table IV. The agreement in resistance, running angle and stability was very satisfactory. Results obtained in trial flights with America and P/5 machines have also confirmed isolated detail predictions based on tank experiments, and warrant the use of model results for estimating works.

§17. *Wing Floats.*—These are secured to the underside of the lower wing, immediately below one of the struts. When planing at high speeds, both wing floats should be

When lying at rest, with one wing float in the water, the tip of the after edge of the wing should be 2 ft. to 3 ft. above the water to be clear of waves. If the machine is to be anchored out, there should be such reserve buoyancy in the wing float that, with a heavy cross wind, the leeward wing should still be above ordinary waves. For the purpose of calculating the required reserve buoyancy it has been assumed at the Tank (1) that the machine has pitched to an angle of about 12 deg. on the wing chord (or about 7 deg. above the "at rest" angle); (2) that a 25-knot breeze produced a lift on the wings of 2·5 lb. per square foot, and (3) that the centre of pressure of both wings on the windward

side was one-third their length from the tip, and on the leeward side one-third their length from the hull. Knowing the wing surface the tipping moment for a 25-knot breeze can be obtained, and the buoyancy required at the wing float position is then easily obtained. The clearance of the wing tip, when the wing float is immersed to give this extra buoyancy would depend upon the service and size of the machine. Consistent with satisfying these requirements its cross-section area should be kept as small as possible, so as to avoid wastage of wing surface (shrouded by the float) and head resistance.

TABLE IV.—*Comparison o Model Estimate and Actual Results.*

Machine Speed.	Water Resistance from Model Results.	Estimated Air Resistance of Machine.	Total Estimated Resistance.	Actual Measured Pull.	Wing Chord Angle.	
					Measured.	From Model Tests.
knots.	lb.	lb.	lb.	lb.	deg.	deg.
9·3	455	33	488	560	12·0	11·3
11·5	520	52	572	640	13·1	12·3
14·5	678	80	760	670	12·7	12·7
15·2	705	95	801	760	14·6	13·0
17·0	678	133	811	850	14·7	14·5
19·3	680	181	861	870	15·9	15·0
20·2	679	201	880	870	15·8	15·1
24·8	—	—	—	—	14·2	15·1

The speed at which the main step cleared was 12·7 knots when taxi-ing (wing chord 12·1 deg.) and 11·5 knots when towed (wing chord 13·1 deg.). Model tests gave this sped as 13 knots with angle of wing chord 13·5 deg.

A model was dropped on the water whilst moving at various horizontal speeds. The attitude of model and height of drop have been varied, so that the direction of motion, and the angle at which the bottom struck the water were varied. The blow was ascertained by measuring the deceleration on impact and taking the force to be the product of virtual mass and deceleration. Three types of bottom were tried, having perfectly flat, straight V and hollow V cross-sections. The results were expressed by the following formula :—

$$\text{Maximum blow in lb.} = P = \Delta \frac{5}{6} V_R \frac{x-1}{x^2} k$$

Δ being the displacement in pounds.

V_R the resultant velocity of the float in knots.

$x = \dfrac{\text{forward velocity on impact.}}{\text{vertical velocity on impact.}}$

k = a constant.

The constant k to be used varies a little with attitude of hull at impact and type of section, and is given below.

—	Hull having Cross-Section at Step Plain V of Degrees.		Hull having Hollow Cross-Section nearly Horizontal.	
			At Chine.	Degrees at Keel.
Angle of step to horizontal ..	3 deg.	6 deg.	3 deg.	6 deg.
Constant k ..	3·1	3·4	2·0	2·4

The flat bottom was about 40 per cent. worse than the form with plain V at high speed, but the difference diminished as speed was dropped.

TABLE V.—SOME TYPES OF FLYING BOATS.

Designed and constructed by the firms named.

The speed given is that for leaving the water, normally slightly above the minimum speed for the machine.

Dimensions in Feet and Pounds.

Type	Viking.	Valentia.	Vigilant.	Baby.	Sea Lion.	Bat Boat.
Designed and made by.. ..	Messrs. Vickers, Son, and Maxim			Supermarine Aviation Co.		Sopwith Aviation Co.
Displacement, lb. normal cargo	3,200	18,300	101,000	2,300	—	2,150
Brake horse-power	270	1,300	5,200	—	—	100
No. of propellers	1	2	4	1	—	1
Speed, getting-off, in knots ..	48	52	49·5	About 50	Attained 128 on trial	—
Hull—Length overall	30·2	53·0	120·0	26·0	—	18·0
Length (stem to step) ..	10·7	21·6	42·9	—	—	11·2
Beam	4·0	9·0	20·0	—	—	4·0

Phœnix cork has the hull called P/5 in the paper.
Channel 4-seater is somewhat similar to the A.D. type.
The Sopwith Bat boat, started from the sea and settled on the land, and started from the land and settled on the sea in 1913.
The Supermarine Baby was looped twice in February, 1918.

§18. *Stresses on the Float Hull due to Water Action.*—To determine the stresses coming on a hull as a whole, the ordinary bending moment calculations have been made for a hull supported on wave crests at each end, and with the wave hollow amidships just touching the keel. Expressed in terms of the length L and displacement Δ this gave a bending moment of $\frac{\Delta L}{11{\cdot}4}$. If pitching takes place, dipping by the bow increases the virtual weights of all the parts forward and decreases at the stern. The line of action of the virtual gravity force of any weights w at y ft. above or below the centre of gravity, is such as to give a horizontal component of $+\frac{w}{g} y \frac{d^2\theta}{dt^2}$, where $\frac{d^2\theta}{dt^2}$ is the angular acceleration. Taking this to be 0·4 radius per second, the calculation has been made for the above machine in waves. The additional bending moment is not more than 1 per cent. or 2 per cent. in this case, but may amount to 17 per cent. with other waves.

If the machine is heaving so that it just does not leave the water, the water force will vary from nil to twice its steady value, and the vertical loads will be correspondingly increased, giving a B.M. of $\frac{1}{5{\cdot}7} \Delta L$. When heaving with longitudinal motion, although local forces may be increased, the general B.M. is less. This statement is based on a calculation for the above machine at 20 knots, moving with a maximum vertical motion of 3 ft.-sec. The actual angle of attack of the planing bottom varied from 14 deg. to 4 deg., its normal angle at this speed being 9 deg. The forces at various immersions, and relative motions have been calculated, and the B.M. obtained in this way was $\frac{1}{4}$ of ΔL. The worst B.M. likely to be met is of the order of 1/5 Δ L. No general system of calculating these stresses on the hull has been adopted so far, and it would appear that until further knowledge has been obtained, the worst B.M. may be taken as twice that obtained in the ordinary case detailed at the beginning of this paragraph.

§19. The maximum blow received by a hull when settling on the water, would depend upon the direction of motion at the time of contact. Generally speaking, it would be received in the neighbourhood of the step, and the worst case would be, if it were taken wholly there. Experiments have been made in the tank to measure the magnitude of this blow, and the extent to which it varies with shape of section at the step. A machine of 10,000 lb. weight, planing down at an angle of 1/20, float bottom inclined at 6 deg., at a speed of 55 knots, would therefore strike the water with a maximum blow of 16,400 lb. or 13,500 lb., according to shape of bottom, and this would be concentrated over the full width of the bottom for about 2 ft. to 3 ft. forward of the step.

It is difficult to calculate what the local forces would amount to, either when taxi-ing or settling. Recent experiments with full-size machines have shown that these forces seldom exceed 2 lb. to 4 lb. per square inch, the sea surface being nearly smooth. They were sufficient to produce marked panting motion in the bottom of the machine used—and to produce leakage. Owing to damage of the machine, similar experiments in rough water have not yet been made.

We supplement the illustrations in the paper by three photographical views of flying boats on the opposite page.

METALLOGRAPHICAL STUDY ON GALVANISED STEEL.*

By Y. TAJI, Constructor-Lieutenant, I.J.N., Member.

To galvanise steel materials as a protection from its corrosion is a popular practice in dockyards as well as in iron firms. Particularly for ships of extremely light scantlings as destroyers it is the essential thing for their protection from corrosion.

The practice of galvanising steel is a very simple and well-known matter, but with regard to the metallographical structure and its effect on the strength, there have been few publications dealing with the matter in detail, although it is already known that the galvanised iron has in general two layers of the coating near its surface, i.e., iron-zinc alloy and zinc itself.

1. *Iron-Zinc Alloy.*—The chemical properties of the iron-zinc compounds or the alloy are not very popularly known, even in technical circles. The only thorough paper which deals with the problem very clearly is that of Mr. Vegesack†, so far as the author is aware.

The existence of a chemical compound of iron and zinc has been proved by several investigators by analysing the deposit on the bottom of a zinc-melting bath made of iron.

These compounds were of 5 per cent. to 6·24 per cent. of iron, 99·76 per cent. to 93·01 per cent. of zinc, with a very small quantity of carbon or some other impurities. From Vegesack's investigation we know—

1. The alloy of iron and zinc with 11 per cent. to 24 per cent. of Fe consists of some unknown crystals and liquid in a temperature about 777 deg. C. At 777 deg. C. the crystals and liquid form a compound $FeZn_3$.

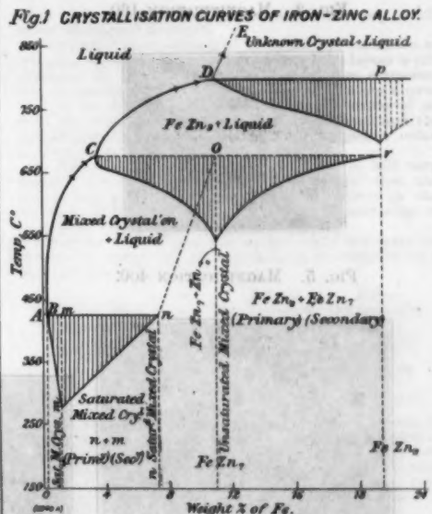
2. The properties of alloy with 0·7 per cent. to 11 per cent. Fe are rather complicated :—

(*a*) With Fe above 3·5 per cent., it generally consists of $FeZn_3$ and liquid at a temperature between 662 deg. and 777 deg. C. At 662 deg. C. they will form a compound, $FeZn_7$.

(*b*) At a temperature between 422 deg. and 662 deg. C. it consists generally of $FeZn_3$ and $FeZn_7$, or their mixed crystals.

(*c*) At 422 deg., the alloy with 7·3 per cent. of Fe forms a certain saturated mixed crystal called "n," consisting of $FeZn_3$ and $FeZn_7$. At about 275 deg., the alloy with 0·7 per cent. of Fe forms another saturated mixed crystal "m," having different disposition of $FeZn_3$ and $FeZn_7$. The mixed crystal "n" is a very hard and brittle material, but "m" is only a little harder than pure zinc.

Fig. 1 CRYSTALLISATION CURVES OF IRON-ZINC ALLOY.



The solidification curve is given in Fig. 1. The microstructure of iron-zinc alloy is quite different from the ordinary zinc structure. Fig. 4 shows a typical structure of Fe-Zn alloy with mixed crystals of "m" and "n." This material is fairly brittle, so that we can easily break it by striking with a small hammer. The microstructure of zinc which I have used for the present experiment is shown in Fig. 5.

2. *General Construction of the Microstructure of Galvanised Steel.*—A number of small mild steel blocks of cubical shape with sides about $\frac{1}{4}$ in., taken from a rectangular rolled bar, were pickled by strong hydrochloric acid until their surfaces became quite clean, and then were washed thoroughly by water. After drying them perfectly, they were immersed in a molten-zinc bath whose temperature was nearly 650 deg. C.

The typical structures of galvanised steel are shown in Figs. 2 and 3. It will be seen that it consists of three layers. "a" is the layer which is directly in contact with the steel surface S. This is a very hard and brittle layer, and its direction of crystallisation is always perpendicular to the steel surface. As I have mentioned already, even a deposit on the bottom of a melting bath which was used for a long time, does not contain more than 6·5 per cent. of iron, so that it will be evident that these layers will not possibly contain more than that quantity of iron. Comparing the structure of the first layer "a" with those obtained by the chemical study on the iron-zinc compounds, it appears to be an iron-zinc alloy with about 5 per cent. of iron. This layer consists of a greater part of "n" crystals and a smaller amount of "m" crystals.

The cleavage line of the crystals is weakest in the direction perpendicular to the steel surface, so that this layer will separate into numerous parts by shock or strain. But as it is an altogether brittle material, they will be broken into several blocks as shown in Fig. 19.

The second layer "b" is generally granular structure as conglomerate. It is evident that this layer is also iron-zinc alloy of less Fe contents. This layer appears to contain about 2 per cent. of iron. It is not so hard or brittle as the layer "a," and is not broken easily by shock or strain. The greater part consists of "m" crystal, and there will be a reduced amount of "n" crystals.

The structure of this layer is very similar to an iron-zinc alloy which is shown in Fig. 4. Sometimes this layer consists of numerous hexagonal grain structures of less iron contents which may be considered practically

* Paper read before the Society of Naval Architects, Japan.

† See *Zeitschrift für Anorganische Chemie*, Band lii, page 30, 1907, "Uber Zinc-Thallium und Zink-Eisenlegierungen," Von A. V. Vegesack.

METALLOGRAPHICAL STUDY ON GALVANISED STEEL.

(*For Description, see Page 327.*)

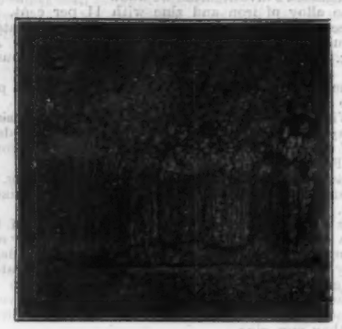


Fig. 2. Magnification 160.

Fig. 5. Magnification 400.

Fig. 3. Magnification 400.

Fig. 4. Magnification 400.

Fig. 6. Magnification 400. Time 15 Minutes.

Fig. 7. Magnification 240. Time 15 Minutes.

Fig. 8. Magnification 400. Time 45 Minutes.

Fig. 9. Magnification 400. Time 45 Minutes.

Fig. 10. Magnification 320. Time 60 Minutes.

Fig. 11. Magnification 400. Time 90 Minutes.

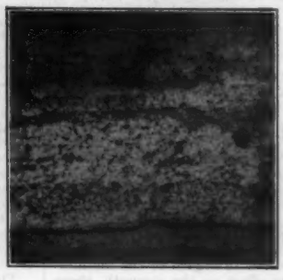


Fig. 12.

Fig. 13.

Fig. 14.

All Specimens Etched by Picric Acid and Illuminated Vertically.

as "m" crystals. The third layer "c" is zinc itself, which generally has small grain structure as shown in Fig. 5. Generally, the contact boundary of "a" and "b" layers is distinct, but "b" structure will be gradually shaded off towards zinc.

3. *The Effect of Zinc for Galvanisation.*—In order to investigate the alteration of the structure due to the duration of galvanisation, specimens were kept in the zinc bath from 15 minutes to 150 minutes. The general feature will be seen from Figs. 6 to 11.

In 15 minutes, the majority may be considered as "m" crystals with a small amount of "n" crystals, as shown in Fig. 6. But they will not lose the characteristic feature of the formation of layers, as previously explained. (See Fig. 7.)

Generally speaking, under 30 minutes, the formation of layers is not so perfect as shown in a typical case (Fig. 2). The absorption of Fe from steel will not exceed more than 3 per cent., so that the first hard laminated structure of "m" crystals is not formed to any great extent, but is only located along the steel surface.

At 45 minutes the formation of the typical structures is quite perfect, and the amount of absorption of Fe from steel is evidently more than 5 per cent., as in Figs. 8 and 9. The laminated hard layer "a" sometimes will have an irregular broken structure when the surface of the steel is very rough, as it has more freedom for crystallisation than on a smooth surface where there is no space for the escape of the zinc-alloy

METALLOGRAPHICAL STUDY ON GALVANISED STEEL.

FIG. 15. SHOWING SEGREGATION OF FERRITE.

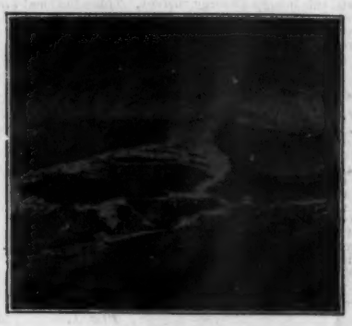
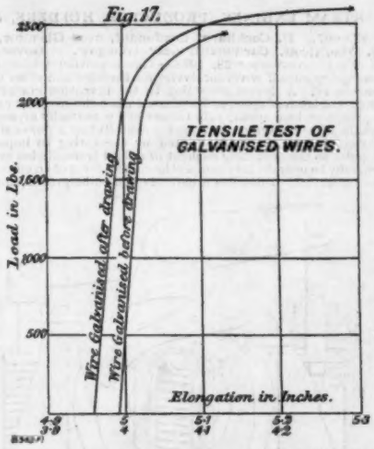
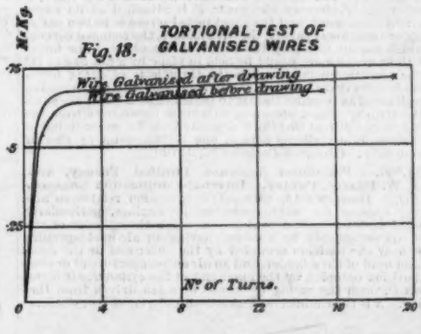


FIG. 16. SAME AS FIG. 15 TO A GREATER MAGNIFICATION.

FIG. 19.





solution. In some cases, however, this is partly due to high brittleness of this layer, and these layers are often broken into pieces while polishing, as shown in Fig. 11.

After 60 minutes, the general feature of the layers is not materially altered, except in the increase of thickness of the iron-zinc alloy layers. But the special phenomena due to the long immersion is the penetration of zinc into steel as shown in Fig. 10. This phenomena happens sometimes even in a short immersion, but it becomes very remarkable after 45 minutes. This seems to happen through the decarburising effect of zinc, as well as being due to the existence of the weak decayed part of the steel on the surface, accompanied by the natural defects or small inlets on the original surface of steel.

One or two specimens were carefully filed to take off some of the thickness of the upper surface of the steel. Then the penetration of zinc was practically nil. Thus it may be considered that a certain amount of the penetration of zinc into steel will generally happen in the ordinary galvanising process.

4. *Galvanised Steel Wires.*—Owing to the extraordinary increase in the use of galvanised steel wire, the study on the effect of galvanisation on its strength and its structure will not be of small importance. Particularly for the naval services, practically all steel wires are galvanised in order to avoid corrosion.

Generally speaking, there are two methods of galvanising steel wires. As these wires are generally hard drawn, the first method is to galvanise wires before they are drawn, and the second method is after drawing.

The construction of structure near the surface of the wire is practically similar to the previous cases which I have already explained. Fig. 12 shows the structures of zinc and its iron alloy in the vicinity of the surface of the wire, which was galvanised after drawing. Fig. 14 shows the structure of the galvanised part of the wire which was galvanised before drawing. In this case it will be seen that the whole zinc-iron alloy and zinc layers are shifted gradually against the direction of drawing.

Figs. 15 and 16 show the structure of steel wire near the surface. It is possible to see clearly the segregation of ferrite. By galvanising steel wires, the segregation of ferrite will occur more or less, firstly owing to high heating of steel, secondly by the decarburising effect of zinc.

Comparing this phenomena with the penetration of zinc into steel, we find that this segregation is quite a different occurrence which will probably happen with higher carbon or some special steels. Referring to the two methods of galvanisation, the first is generally considered the better, as the wire is not heated in a zinc-bath after it is drawn, so that the reduction of strength due to reheating should not occur.

The results given in the next column show a tensile and a torsional test. The torsional test was carried out by an Amsler's torsion machine and the tensile test by a 5-ton Buckton machine.

Curves of the above tests are given in Figs. 17 and 18.

From the above results the first method which we supposed to be superior, unfortunately gives an inferior result. The main cause will most probably be that the wire in the first method was kept too long in molten zinc. In Fig. 14 the first layer has iron-zinc alloy structure of higher content of Fe than that in Fig. 12. The segregation of ferrite in the first method as shown in Figs. 15 and 16 is also more serious than that in the first method.

(A) *Tensile Test.*

	First Method. Wire Galvanised before Drawing.	Second Method. Wire Galvanised after Drawing.
Gauge length, in ins. ...	3·99	4·96
Diameter in ins.... ...	0·128	0·1295
Young's modulus, E in lb./sq. in	$21·15\times10^6$	$24·5\times10^6$
Elastic limit, in tons/sq. in.	58·0	58·2
Ultimate strength in tons/sq. in.	85·0	87·8
Percentage elongation ...	2·88 per cent	5·76 per cent.

(B) *Torsional Test.*

	Wire Galvanised before Drawing.	Wire Galvanised after Drawing.
Length, in ins.	6·25	7·5
Diameter, in ins. ...	0·128	0·1295
(i) Within elastic limit.		
Torque, ft.-lb. ...	3·34	4·08
No. of turns twisted	0·221	0·244
Shearing strength, tons/sq. in. ...	43·45	51·5
Modulus of rigidity, lb./sq. in.	$6·85\times10^6$	$8·72\times10^6$
(ii) Beyond elastic limit.		
Torque, ft.-lb. ...	4·84	5·20
Maximum shearing strength, tons/sq. in.	63·0	65·75
No. of complete turns	15·3	19·0

The original nature of the steel in both cases is quite identical. Its microstructure is shown in Fig. 13. Unfortunately the author was unable to obtain the same ungalvanised steel wire, so that a comparison with naked wire was not possible, but it will be easily understood that the method of galvanisation will very much affect its original strength.

Although I have explained in detail the structure of iron-zinc layers, the perfect formation of the layers is not necessary for the purpose of protection from corrosion, but the essential thing is not to cause any serious alteration in its strength. Thus in such a fine material as wire, the time of immersing it in a zinc bath and the galvanising method must be carefully studied in order to obtain the best results.

5. *Effect of Galvanisation on Strength.*—It will very possibly be understood from the foregoing that the galvanising process will have a great effect on the strength of the steel, especially if it is a special steel or of minute thickness.

Owing to lack of time, the author could not carry on the test in detail, but the following is an example on a statical test of a mild steel bar :—

Item.	Before Galvanisation.	After Galvanisation.
Ultimate strength ...	25·2 tons/sq. in.	24·0 tons/sq. in.
Yielding point	22·0	19·0 tons/sq. in.
Elongation on 10 diameters	24·7	25·0 per cent.

As similar reduction of the strength also appears to happen in an alternating stress test. By alternative application of stress to a galvanised steel, the first hard layer of iron-zinc alloy will be broken into several portions owing to its brittleness, although the zinc layer still remained intact. The feature is clearly shown in Fig. 19.

The author desires to express thanks to Dr. B. P. Haigh, of the Royal Naval College, Greenwich, for his valuable help and suggestions, as well as his kind encouragement, and also to Mr. F. J. A. Pound for his most valuable co-operation.

"THE RUBBER AGE."—We have received a copy of the first issue of this new monthly, which is published at 43, Essex-street, Strand, W.C. 2, at the price of 1*s.* It deals with indiarubber in all its multitudinous applications, the rubber trade, inventions and legal cases connected with rubber, and contains a large amount of useful information for readers directly and indirectly interested in this particular industry.

HIGH SPEED FLYING.—We are informed by the Fiat Company that another world's record has been broken by the Italian aviator Lieutenant Brack-Papa. On February 26, flying an Arf biplane, with four passengers aboard, he was officially timed to do 161¼ miles an hour. The flight was made from the Mirafiori aerodrome, in the suburbs of Turin, and was controlled by the Aero Club of Italy. The Arf machine, a high-speed long distance cruiser, is built by the Fiat Company and is driven by a Fiat 12-cylinder 750 h.p. engine. This machine which is capable of a non-stop flight of 2,500 miles in 19 hours, already holds the world's speed record of 166 miles an hour with pilot only aboard.

UNIVERSITY COLLEGE, LONDON, ENGINEERING FUND.—His Royal Highness Prince Arthur of Connaught will preside, on March 19, at a luncheon to be held at the Savoy Hotel, when the proposals for the reconstruction and the re-equipment of the engineering laboratories at University College, London, will be explained by the treasurer, Sir Ernest Moir, and others. Invitations will be issued in a few days. It will be remembered that an appeal for 100,000*l.* towards this object was recently issued. Already over 33,000*l.* has been collected, that is about one-third of the total sum required. It is urgently necessary that the whole fund should be subscribed by June at the latest, in order that the buildings may be put in hand. Further donations should be sent to H.R.H. Prince Arthur of Connaught, at 42, Upper Grosvenor-street. It is hoped that a prompt and generous response to this appeal will enable His Royal Highness to announce at the luncheon on March 19 a very substantial increase of the fund. A number of engineering firms have recently responded by sending donations.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

135,669. H. Wade, London (*Fabrica Isolatori Livorno, Leghorn, Italy*). **Insulators.** (2 *Figs.*) December 19, 1918.—This invention relates to the mounting of insulators for supporting high-tension electric cables. A porcelain insulator for supporting high-tension electric cables comprises, according to this invention, a thin metal sheet shaped to fit on and cover a large area of the upper surface of the insulator, the collar or binding wire fixing the cable to the insulator being mounted on the said metal sheet.

Fig. 1.

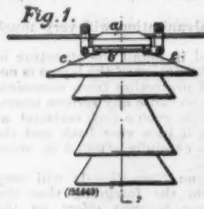


Fig. 2.

a indicates the insulator, *b* the collar or binding wire, *c* the metal sheet on the outside of the cup, and *d* and *d*1 the inside metal sheets. The metal sheet *c* and *d* increases the area of the surface of the porcelain which is subjected to the electrostatic stress, thus diminishing the said stress per unit of surface and improving the working conditions of the insulator. The metal sheet may be conveniently replaced by conductive metallic varnish located on the outside of the cup and on the surfaces between the parts of the insulator. (*Accepted December* 10, 1919.)

135,747. P. F. Brittain, London. Rotors. (2 *Figs.*) April 4, 1919.—The invention refers to rotors of the kind in which conducting rings are provided at and spaced from the ends of same, and flat strip conductors carried by and extending beyond the bodies of the rotors are secured by their ends to said rings.

Fig. 1.

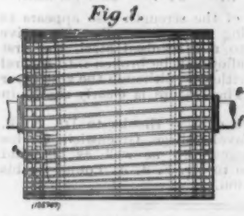
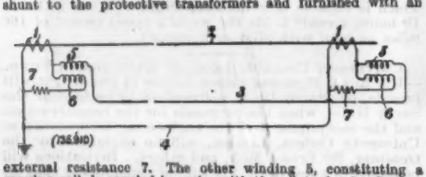


Fig. 2.

In the improved rotor provided by the present invention a plurality of spaced flat rings *e* are provided at one or both ends of the rotor and radial slots *f* are formed in the or each set of rings and in line with one another, in which slots the corresponding ends of the flat strip conductors *c* are fitted and secured. (*Accepted December* 10, 1919.)

135,910. The British Thomson-Houston Company, Limited, London, and E. B. Wedmore, Golder's Green. Alternating Electric Current Distribution Systems. (1 *Fig.*) November 29, 1918.—The invention consists in employment of relays having the general characteristics of wattmeters, but so adjusted as to be inoperative on a current flowing in the pilot wire circuit due to capacity alone. Protective transformers 1 are connected as usual in circuit, one at either end of the feeder 2, with one end of each coupled through a pilot wire 3, so that the transformers are normally in opposition, and the other end of each coupled through a return wire 4, which may be earthed as shown. According to the invention, a relay constructed on the lines of a dynamometer having two windings, 5 and 6, connected as indicated in the diagrams, is used. One of these windings 6, constituting a field coil, is connected in shunt to the protective transformers and furnished with an



external resistance 7. The other winding 5, constituting a moving coil, is coupled in series with the pilot wire 3. So long as the feeder is sound, the protective transformers act as potential transformers and apply potential to the windings. The current in the field winding will be proportional to the applied potential, this winding being in direct shunt to the transformer. The current in the other winding will be that due to the capacity between the pilot wire and earth, and will again be proportional to the applied potential. The current in the pilot wire circuit will be a leading current, leading by some amount less than 90 deg., due to the resistance of the pilot wire circuit. The circuit, consisting of the field winding, together with its external resistance, must have its power factor adjusted so that the angle of lag is at least as great as the angle obtained by subtracting the angle of lead in the pilot wire circuit from 90 deg. With this arrangement, and assuming a small margin of difference between the angles is provided for safety, the moving coil will show a tendency to move in one direction under normal conditions, but in the event of a leak in the main feeder resulting in diminution or reversal of the current in one of the two protective transformers, a correspondingly additional current will flow in the pilot wire circuit, this being an energy current. This additional current will reduce the lead of the current in the pilot wire circuit and result in reversal of the direction of motion of the moving coil. The moving coil is arranged to move so as to actuate a circuit-closing device on a leak occurring. (*Accepted December* 17, 1919.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

136,088. F. H. De Veulle, Handsworth, Birmingham. Carburettors. (3 *Figs.*) May 6, 1919.—According to this invention, the screen and filter are of horseshoe or part-circular shape, their axes are at right angles to the air flow, and they are placed concentrically with the throttle, or approximately so when the latter is of sleeve form. This screen is made of sheet metal, and is without apertures opposite the actual air inlet, so that the air has to make a bend inside the screen as it enters the carburettor as also has the mixture blown back from the carburettor. The fuel is admitted through the passage A into the spraying chamber B. The mixture is under the control of a sliding throttle valve C and issues by the branch D to the engine, whilst the air enters at E. The gauze is indicated at F, and the screen at G, both being of

Fig. 1.

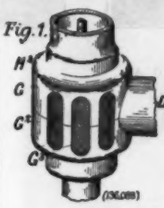
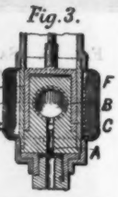


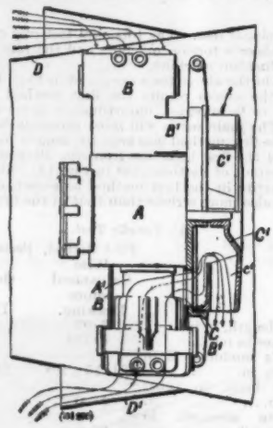
Fig. 2.

Fig. 3.



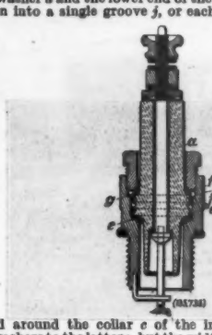
horseshoe shape and mounted concentrically around the throttle chamber H. Preferably the gauze F is attached at its edges to a light framework, and the sheet metal screen is in two parts, an upper and a lower part G, G2, with flanges, the rounded corners of which engage and grip the frame of the gauze. The upper part G, in such a case, would be held in place by a nut or cap H2 on the throttle chamber, when the throttle is of sleeve form. It will be seen that the screen G, G2, is formed with apertures G3, so positioned as to cause the air to take a curved path, as shown by the arrows. Thus, when any mixture is blown back from the carburettor, the fuel therein is deposited on the gauze lining of the screen by centrifugal action, and is picked up by the air passing later. (*Accepted December* 17, 1919.)

135,980. Palladium Autocars, Limited, Putney, and D. J. W. Baxter, Putney. Internal-Combustion Engines. (1 *Fig.*) December 18, 1918.—This invention relates to air-cooling systems for internal-combustion engines, particularly those of motor-propelled vehicles, in which the cylinder of the engine is surrounded by a casing having an air-inlet aperture at or near the position occupied by the outer end or the combustion head of the cylinder, and an air outlet aperture at or near the position occupied by the inner end of the cylinder, air being drawn through the casing by means of a fan driven from the engine. A is the engine crank-case and A1 is one of its cylinders,



B, B are the casings surrounding the cylinders, each casing having an open end by which air can enter and a lateral aperture B1 by which the air can pass from the casing. C is a chamber with which the lateral aperture B1 of each casing communicates, and C1 is the flywheel which rotates in this chamber and acts as a fan for which purpose it is provided with vanes connecting the hub and rear portion to the rim and front portion. The bonnet D of the vehicle has louvres D1, D1, which are made in the reverse direction from that which is customary when louvres are employed, so as to direct air towards the open ends of the casings B, B. The arrows in the drawing show approximately the course of the cooling air. (*Accepted December* 17, 1919.)

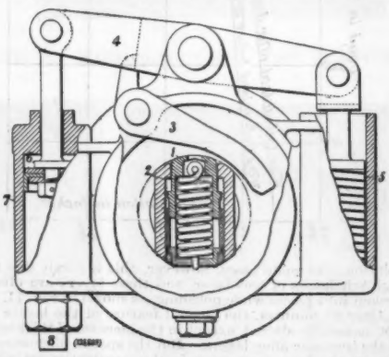
135,735. J. Suckling, Birmingham, and B. Carter, Birmingham. Sparking Plugs. (3 *Figs.*) March 7, 1919.—This invention relates to sparking plugs of that type in which the insulator is removably held within the metal body by means of a gland nut engaging a metal-asbestos packing washer upon the outer side of a collar upon the insulator, another packing washer being interposed between the underside of the said collar and an internal seating within the metal body. That part of the insulator *a* has a collar *c*. To the lower end of this collar is applied an angle-sectioned sheet-metal packing washer *d* containing a ring of asbestos *e* adapted to come against the underside of the collar *c*, the lower side of the washer being engaged with a seating around the interior of the body *b*, whilst the lateral portion encircles the outside of the collar *c*. To the upper end of the latter is applied a cylindrical stepped washer *f*, of two diameters, the smaller diameter encircling the main portion of the insulator and the larger diameter surrounding the collar *c*, whilst beneath the shoulder is a ring of asbestos *g* engaging the upper end of the collar. A gland nut screwed into the meta body engages the shoulder of the upper washer *f* and compresses the asbestos of both washers when the parts of the plug are assembled. According to the invention, the upper end of the lower washer *d* and the lower end of the upper washer *f* are closed or spun into a single groove *j*, or each into a separate groove,



formed around the collar *c* of the insulator, thereby locking both washers to the latter; but the width of the groove or grooves and the clearance between the washers is such as to allow of a certain amount of free play or movement of the turned-in edges of the washers in an axial direction, in order to permit of the compression of the asbestos when the plug is assembled. (*Accepted December* 10, 1919.)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

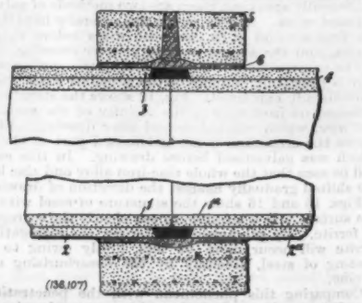
135,607. D. Cockburn, Cardonald, near Glasgow, and D. MacNicoll, Cardonald, near Glasgow. Governors. (1 *Fig.*) November 28, 1918.—This invention relates to an emergency cut-off governor device for turbines and other rotary machinery. A device according to the invention comprises a trigger or latch adapted to be released when the governor exceeds a predetermined speed, said trigger being normally arranged to detain a lever acted on by a spring constituting a power storage device, and serving when rocked by the spring to impart an impulse to the actuating element of a fluid transmission system, whereby to operate for example the control lever of an emergency cut-off device. 1 denotes a bolt adapted to be protruded under



the action of centrifugal force in opposition to a spring 2. In the path of the bolt when protruded to its outermost position is a trigger 3 normally serving to detain a lever 4, of which one end is acted on by a spring 5 under compression and the other end of which is operatively connected to a plunger 6 movable in a cylinder 7, the outlet 8 of which may be connected by piping to an emergency controlling device. It will be understood that when the bolt is protruded on attainment of excessive speed the trigger 3 will be disengaged from the lever 4 which will thereupon be rocked by the spring and impart an impulse to the plunger 6, whereby to bring into operation the emergency controlling device (*Accepted December* 10, 1919.)

MISCELLANEOUS.

136,107. The Firm of Melville Dundas and Whitson, Glasgow, and C. Goodwin, Glasgow. Reinforced Concrete Pipes. (2 *Figs.*) June 5, 1919.—This invention relates to an improved joint for reinforced concrete pipes in which the pipes to be jointed are sleeved by a reinforced collar cast with its axis substantially vertical, the collar being spaced from the outer face of the pipes, and the space between the collar and the pipes being fitted with grouting. 1, 1a denote inner co-axial pipes



disposed in end-to-end abutting relation and embraced by outer pipes 2, 2a, between the adjacent ends of which is presented an undercut annular recess for reception of sealing medium 3. Between the pipes 1, 1a, and the pipes 2, 2a, is a liner 4 of sheet steel. 5 denotes the reinforced collar which, as aforesaid, is cast with its axis vertical. The annular space between the collar 5 and the pipes 2, 2a, is filled with grouting 6. (*Accepted December* 17, 1919.)